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ANTAGONISTS OF MCP-1 FUNCTION AND METHODS OF USE THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority under 35 USC 119(e) of US Provisional Application No. 60/272,792, filed March 1, 2001, which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to compounds which are antagonists of MCP-1 function and are useful in the prevention or treatment of chronic or acute inflammatory or autoimmune diseases, especially those associated with aberrant lymphocyte or monocyte accumulation such as arthritis, asthma, atherosclerosis, diabetic nephropathy, inflammatory bowel disease, Crohn's disease, multiple sclerosis, nephritis, pancreatitis, pulmonary fibrosis, psoriasis, restenosis, and transplant rejection; and to pharmaceutical compositions comprising these compounds and the use of these compounds and compositions in the prevention or treatment of such diseases.

BACKGROUND OF THE INVENTION

Chemokines: Structure and Function

The migration of leukocytes from blood vessels into diseased tissues is an important process in the initiation of normal inflammatory responses to certain stimuli or insults to the immune system. However, this process is also involved in the onset and progression of life-threatening inflammatory and autoimmune diseases; blocking leukocyte recruitment in these disease states, therefore, can be an effective therapeutic strategy.

The mechanism by which leukocytes leave the bloodstream and accumulate at inflammatory sites involves three distinct steps: (1) rolling, (2) arrest and firm adhesion, and (3) transendothelial migration [Springer, *Nature* 346:425-433 (1990); Lawrence and Springer, *Cell* 65:859-873 (1991); Butcher, *Cell* 67:1033-1036 (1991)]. The second step is mediated at the molecular level by chemoattractant receptors on the surface of leukocytes which bind chemoattractant cytokines secreted by proinflammatory cells at the site of damage or infection.

Receptor binding activates leukocytes, increases their adhesiveness to the endothelium, and promotes their transmigration into the affected tissue, where they can secrete inflammatory and chemoattractant cytokines and degradative proteases that act on the subendothelial matrix, facilitating the migration of additional leukocytes to the site of injury.

The chemoattractant cytokines, collectively known as "chemokines," are a large family of low molecular weight (8 to 10 kD) proteins that share the ability to stimulate directed cell migration ("chemotaxis") [Schall, *Cytokine* 3:165-183 (1991); Murphy, *Rev Immun* 12:593-633 (1994)].

Chemokines are characterized by the presence of four conserved cysteine residues and are grouped into two main subfamilies based on whether the two amino-terminal cysteines are separated by one amino acid (CXC subfamily, also known as α-chemokines) or immediately adjacent to each other (CC subfamily, also referred to as β-chemokines) [Baggiolini et al., *Adv Immunol* 55:97-179 (1994); Baggiolini et al., *Annu Rev Immunol* 15:675-705 (1997); Deng et al., *Nature* 381:661-666 (1996); Luster, *New Engl J Med* 338:436445 (1998); Saunders and Tarby, *Drug Discovery Today* 4:80-92 (1999)].

The chemokines of the CXC subfamily, represented by IL-8, are produced by a wide range of cells and act predominantly on neutrophils as mediators of acute inflammation. The CC chemokines, which include MCP-1, RANTES, MIP-1α, and MIP-1β, are also produced by a variety of cells, but these molecules act mainly on monocytes and lymphocytes in chronic inflammation.

Like many cytokines and growth factors, chemokines utilize both high and low affinity interactions to elicit full biological activity. Studies performed with labeled ligands have identified chemokine binding sites ("receptors") on the surface of neutrophils, monocytes, T cells, and eosinophils with affinities in the 500 pM to 10 nM range [Kelvin et al., *J Leukoc Biol* 54:604-612 (1993); Murphy, *Annu Rev Immunol* 12:593-633 (1994); Raport et al., *J Leukoc Biol* 59:18-23 (1996); Premack and Schall, *Nature* Med 2:1174-1178 (1996)]. The cloning of these receptors has revealed that cell surface high-affinity chemokine receptors belong to the seven transmembrane ("serpentine") G-protein-coupled receptor (GPCR) superfamily.

Chemokine receptors are expressed on different cell types, including non-leukocyte cells. Some receptors are restricted to certain cells (*e.g.*, the CXCR1 receptor is predominantly

restricted to neutrophils), whereas others are more widely expressed (*e.g.*, the CCR2 receptor is expressed on monocytes, T cells, natural killer cells, dendritic cells, and basophils).

Given that at least twice as many chemokines have been reported to date as there are receptors, there is a high degree of redundancy in the ligands and, not surprisingly, most chemokine receptors are rather promiscuous with regard to their binding partners. For example, both MIP-1α and RANTES bind to the CCR1 and CCR5 receptors, while IL-8 binds to the CXCR1 and CXCR2 receptors. Although most chemokines receptors bind more than one chemokine, CC receptors bind only CC chemokines, and CXC receptors bind only CXC chemokines. This ligand-receptor restriction may be related to the structural differences between CC and CXC chemokines, which have similar primary, secondary, and tertiary structures, but different quaternary structures [Lodi et al., *Science* 263:1762-1767 (1994)].

The binding of chemokines to their serpentine receptors is transduced into a variety of biochemical and physiological changes, including inhibition of cAMP synthesis, stimulation of cytosolic calcium influx, upregulation or activation of adhesion proteins, receptor desensitization and internalization, and cytoskeletal rearrangements leading to chemotaxis [Vaddi et al., *J Immunol* 153:4721-4732 (1994); Szabo et al., *Eur J Immunol* 27:1061-1068 (1997); Campbell et al., *Science* 279:381-384 (1998); Aragay et al., *Proc Natl Acad Sci USA* 95:2985-2990 (1998); Franci et al., *J Immunol* 157:5606-5612 (1996); Aramori et al., *EMBO J* 16:4606-4616 (1997); Haribabu et al., *J Biol Chem* 272:28726-28731 (1997); Newton et al., *Methods Enzymol* 287:174-186 (1997)]. In the case of macrophages and neutrophils, chemokine binding also triggers cellular activation, resulting in lysozomal enzyme release and generation of toxic products from the respiratory burst [Newton et al., *Methods Enzymol* 287:174-186 (1997); Zachariae et al., *J Exp Med* 171:2177-2182 (1990); Vaddi et al., *J Leukocyte Biol* 55:756-762 (1994)]. The molecular details of the chemokine-receptor interactions responsible for inducing signal transduction, as well as the specific pathways that link binding to the above-mentioned physiological changes, are still being elucidated. Notwithstanding the complexity of these events, it has been shown that in the case of the MCP-1/CCR2 interaction, specific molecular features of MCP-1 can induce different conformations in CCR2 that are coupled to separate post-receptor pathways [Jarnagin et al., *Biochemistry* 38:16167-16177 (1999)]. Thus, it should be possible to identify ligands that inhibit chemotaxis without affecting other signaling events.

In addition to their high-affinity seven transmembrane GPCRs, chemokines of both subfamilies bind to various extracellular matrix proteins such as the glycosaminoglycans (GAGs) heparin, chondroitin sulfate, heparan sulfate, and dermatan sulfate with affinities in the middle nanomolar to millimolar range. These low-affinity chemokine-GAG interactions are believed to be critical not only for conformational activation of the ligands and presentation to their high-affinity serpentine receptors, but also for the induction of stable chemokine gradients that may function to stimulate haptotaxis (*i.e.*, the migration of specific cell subtypes in response to a ligand gradient that is affixed upon the surface of endothelial cells or embedded within the extracellular matrix) [Witt and Lander, *Curr Biol* 4:394-400 (1994); Rot, *Eur J Immunol* 23:303-306 (1993); Webb et al., *Proc Natl Acad Sci USA* 90:7158-7162 (1993); Tanaka et al, *Nature* 361:79-82 (1993); Gilat et al., *J Immunol* 153:4899-4906 (1994)]. Similar ligand-GAG interactions have been described for a variety of cytokines and growth factors, including the various members of the FGF family, hepatocyte growth factor, IL-3 and IL-7, GM-CSF, and VEGF [Roberts et al., *Nature* 332:376-378 (1988); Gilat et al., *Immunol Today* 17:16-20 (1996); Clarke et al., *Cytokine* 7:325-330 (1995); Miao et al., *J Biol Chem* 271:4879-4886 (1996); Vlodavsky et al., *Cancer Metastasis Rev* 15:177-186 (1996)].

MCP-1 and Diseases

Chemokines have been implicated as important mediators of allergic, inflammatory and autoimmune disorders and diseases, such as asthma, atherosclerosis, glomerulonephritis, pancreatitis, restenosis, rheumatoid arthritis, diabetic nephropathy, pulmonary fibrosis, and transplant rejection. Accordingly, it has been postulated that the use of antagonists of chemokine function may help reverse or halt the progression of these disorders and diseases.

In particular, elevated expression of MCP-1 has been observed in a number of chronic inflammatory diseases [Proost et al., *Int J Clin Lab Res* 26:211-223 (1996); Taub, D. D. *Cytokine Growth Factor Rev* 7:355-376 (1996)] including rheumatoid arthritis [Robinson et al., *Clin Exp Immunol* 101:398-407 (1995); Hosaka et al., *ibid.* 97:451-457 (1994); Koch et al., *J Clin Invest* 90:772-779 (1992); Villiger et al., *J Immunol* 149:722-727 (1992)], asthma [Hsieh et al., *J Allergy Clin Immunol* 98:580-587 (1996); Alam et al., *Am J Respir Crit Care Med* 153:1398-1404 (1996); Kurashima et al., *J Leukocyte Biol* 59:313-316 (1996); Sugiyama et al., *Eur Respir*

J 8:1084-1090 (1995)], and atherosclerosis [Yla-Herttuala et al., *Proc Natl Acad Sci USA* 88:5252-5256 (1991); Nelken et al., *J Clin Invest* 88:1121-1127 (1991)].

MCP-1 appears to play a significant role during the early stages of allergic responses because of its ability to induce mast cell activation and LTC4 release into the airway, which directly induces AHR (airways hyper-responsiveness) [Campbell et al., *J Immunol* 163:2160-2167 (1999)].

MCP-1 has been found in the lungs of patients with idiopathic pulmonary fibrosis and is thought to be responsible for the influx of mononuclear phagocytes and the production of growth factors that stimulate mesenchymal cells and subsequent fibrosis [Antoniades et al., *Proc Natl Acad Sci USA* 89:5371-5375 (1992)]. In addition, MCP-1 is also involved in the accumulation of monocytes in pleural effusions, which is associated with both *Mycobacterium tuberculosis* infection and malignancy [Strieter et al., *J Lab Clin Med* 123:183-197 (1994)].

MCP-1 has also been shown to be constitutively expressed by synovial fibroblasts from rheumatoid arthritis patients, and its levels are higher in rheumatoid arthritis joints compared to normal joints or those from other arthritic diseases [Koch et al., *J Clin Invest* 90:772-779 (1992)]. These elevated levels of MCP-1 are probably responsible for the monocyte infiltration into the synovial tissue. Increased levels of synovial MIP-1α and RANTES have also been detected in patients with rheumatoid arthritis [Kundel et al., *J Leukocyte Biol* 59:6-12 (1996)].

MCP-1 also plays a critical role in the initiation and development of atherosclerotic lesions. MCP-1 is responsible for the recruitment of monocytes into atherosclerotic areas, as shown by immunohistochemistry of macrophage-rich arterial wall [Yla-Herttuala et al., *Proc Natl Acad Sci USA* 88:5252-5256 (1991); Nelken et al., *J Clin Invest* 88:1121-1127 (1991)] and anti-MCP-1 antibody detection [Takeya et al., *Human Pathol* 24:534-539 (1993)]. LDL-receptor/MCP-1-deficient and apoB-transgenic/MCP-1-deficient mice show significantly less lipid deposition and macrophage accumulation throughout their aortas compared with wild-type MCP-1 strains [Alcami et al., *J Immunol* 160:624-633 (1998); Gosling et al., *J Clin Invest* 103:773-778 (1999); Gu et al., *Mol. Cell.* 2:275-281 (1998); Boring et al., *Nature* 394:894-897 (1998).

Other inflammatory diseases marked by specific site elevations of MCP-1 include multiple sclerosis (MS), glomerulonephritis, and stroke.

These findings suggest that the discovery of compounds that block MCP-1 activity would be beneficial in treating inflammatory diseases.

Antagonists of Chemokine Function

Most chemokine antagonists reported to date are either neutralizing antibodies to specific chemokines or receptor-ligand antagonists, that is, agents that compete with specific chemokines for binding to their cognate serpentine receptors but, unlike the chemokines themselves, do not activate these receptors towards eliciting a functional response [Howard et al., *Trend Biotechnol* 14:46-51 (1996)].

The use of specific anti-chemokine antibodies has been shown to curtail inflammation in a number of animal models (*e.g.*, anti-MIP-1α in bleomycin- induced pulmonary fibrosis [Smith et al., *Leukocyte Biol* 57:782-787 (1994)]; anti-IL-8 in reperfusion injury [Sekido et al., *Nature* 365:654-657 (1995)], and anti-MCP-1 in a rat model of glomerulonephritis [Wada et al., *FASEB J* 10:1418-1425 (1996)]). In the MRL-*lpr* mouse arthritis model, administration of an MCP-1 antagonist significantly reduced the overall histopathological score after the early onset of the disease [Gong et al., *J Exp Med* 186:131-137 (1997)].

A major problem associated with using antibodies to antagonize chemokine function is that they must be humanized before use in chronic human diseases. Furthermore, the ability of multiple chemokines to bind and activate a single receptor forces the development of a multiple antibody strategy or the use of cross-reactive antibodies in order to completely block or prevent pathological conditions.

Several small molecule antagonists of chemokine receptor function have been reported in the scientific and patent literature [White, *J. Biol Chem* 273:10095-10098 (1998); Hesselgesser, *J. Biol Chem* 273:15687-15692 (1998); Bright et al., *Bioorg Med Chem* Lett 8:771-774 (1998); Lapierre, *26th Natl Med Chem Symposium*, June 14-18, Richmond (VA), USA (1998); Forbes et al., *Bioorg Med Chem* Lett 10:1803-18064 (2000); Kato et al., WO 97/24325; Shiota et al., WO 97/44329; Naya et al., WO 98/04554; Takeda Industries, JP 09-55572 (1998); Schwender et al., WO 98/02151; Hagmann et al., WO 98/27815; Connor et al., WO 98/06703; Wellington et al., US 6288103].

The specificity of the chemokine receptor antagonists, however, suggests that inflammatory disorders characterized by multiple or redundant chemokine expression profiles will be relatively more refractory to treatment by these agents.

A different approach to target chemokine function would involve the use of compounds that disrupt the chemokine-GAG interaction. One class of such agents with potential therapeutic application would consist of small organic molecules that bind to the chemokine low affinity GAG-binding domain.

Compounds of this class might not inhibit binding of the chemokine to its high-affinity receptor *per se*, but would disrupt chemokine localization within the extracellular matrix and provide an effective block for directed leukocyte-taxis within tissues. An advantage of this strategy is the fact that most CC and CXC chemokines possess similar C-terminal protein folding domains that define the GAG-binding site, and, hence, such compounds would be more useful for the treatment of inflammatory disorders induced by multiple, functionally redundant chemokines [McFadden and Kelvin, *Biochem Pharmacol* 54:1271-1280 (1997)].

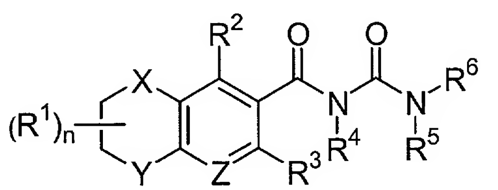
The use of small molecule drugs to bind cytokine ligands and disrupt interactions with extracellular GAGs has been reported with FGF-dependent angiogenesis [Folkman and Shing, *Adv Exp Med Biol* 313:355-364 (1992)]. For example, the heparinoids suramin and pentosan polysulphate both inhibit angiogenesis under conditions where heparin is either ineffective or even stimulatory [Wellstein and Czubayko, *Breast Cancer Res Treat* 38:109-119 (1996)]. In the case of suramin, the anti-angiogenic capacity of the drug has also been shown to be targeted against VEGF [Waltenberger et al., *J Mol Cell Cardiol* 28:1523-1529 (1996)] which, like FGF, possesses heparin-binding domains similar to those of the chemokines. Heparin or heparin sulphate has also been shown to directly compete for GAG interactions critical for T-cell adhesion mediated by MIP-1β *in vitro* [Tanaka et al., *Nature* 361:79-82 (1993)].

The disclosures of all documents referred to throughout this application are incorporated herein by reference.

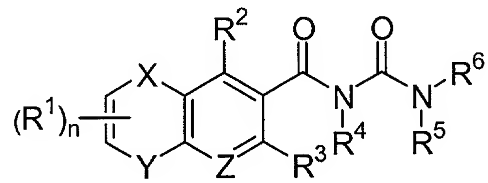
SUMMARY OF THE INVENTION

The present invention relates to compounds that inhibit MCP-1-induced chemotaxis of human monocytic cells both *in vitro* and *in vivo*. These novel MCP-1 antagonists are useful for the treatment of inflammatory diseases, especially those associated with lymphocyte and/or monocyte accumulation, such as atherosclerosis, diabetic nephropathy, inflammatory bowel disease, Crohn's disease, multiple sclerosis, nephritis, pancreatitis, pulmonary fibrosis, psoriasis, restenosis, rheumatoid arthritis, and other chronic or acute autoimmune disorders. In addition, these compounds can be used in the treatment of allergic hypersensitivity disorders, such as asthma and allergic rhinitis, characterized by basophil activation and eosinophil recruitment.

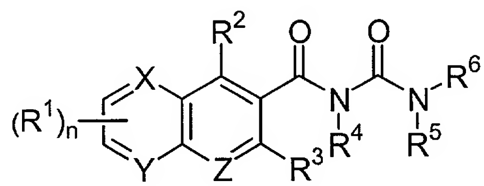
A first embodiment of the present invention provides compounds of Formula I, Formula II, and Formula III:



I



II



III

where:

n is an integer of 0 to 4 in Formula I, and is an integer of 0 to 2 in Formula II and Formula III;

X and Y are independently O, S, CH-R^8, or N-R^7 in Formula I and Formula II, and are independently N and C-R^8 in Formula III;

Z is N or C-R^8;

provided that at least one of X, Y, and Z is a non-carbon ring atom;

each R^1 is independently, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^9$, $-SR^9$, $-NR^9R^{10}$, $-NR^9(CH_2)_{1-6}C(=O)OR^{10}$, $-C(=O)R^9$, $-C(=O)OR^9$, $-C(=O)NR^9R^{10}$, $-OC(=O)R^9$, $-SO_2R^9$, $-OSO_2R^9$, $-SO_2NR^9R^{10}$, $-NR^9SO_2R^{10}$ or $-NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-$N(C_{1-2}$ alkyl$)_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl(lower alkyl), aryl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), $N-(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group, or in Formula I, n=2 and the two R^1's together constitute =O,

R^2, R^3, and R^8 are independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^9$, $-SR^9$, $-NR^9R^{10}$, $-NR^9(CH_2)_{1-6}C(=O)OR^{10}$, $-C(=O)R^9$, $-C(=O)OR^9$, $-C(=O)NR^9R^{10}$, $-OC(=O)R^9$, $-SO_2R^9$, $-OSO_2R^9$, $-SO_2NR^9R^{10}$, $-NR^9SO_2R^{10}$ or $-NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-$N(C_{1-2}$ alkyl$)_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl(lower alkyl), aryl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), $N-(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group,

Each R^7 is independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), halo(lower alkyl), $-C(=O)R^9$, $-C(=O)OR^9$, $C(=O)NR^9R^{10}$, $-SO_2OR^9$, $-SO_2NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-$N(C_{1-2}$ alkyl$)_2$, lower alkyl(optionally substituted heterocycloalkyl),

alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl(lower alkyl), aryl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), $N-(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group,

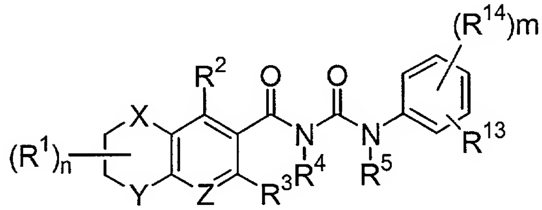
R^4 and R^5 are independently, hydrogen, optionally substituted lower alkyl, optionally substituted aryl, or optionally substituted aryl(lower alkyl), or, together, are $-(CH_2)_{2-4}-$,

R^6 is hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), $-C(=O)R^{11}$, $-C(=O)OR^{11}$, $-C(=O)NR^{11}R^{12}$, $-SO_2R^{11}$, or $-SO_2NR^{11}R^{12}$, wherein R^{11} and R^{12} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^{11} and R^{12} together are $-(CH_2)_{4-6}-$,

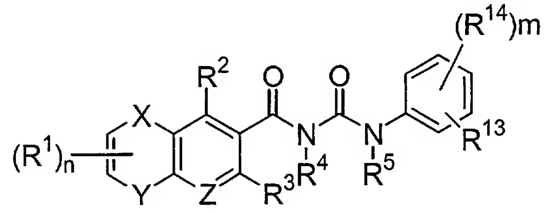
or a pharmaceutically acceptable salt thereof, optionally in the form of a single stereoisomer or mixture of stereoisomers thereof.

The compounds of this invention may possess one or more chiral centers, and can therefore exist as individual stereoisomers or as mixtures of stereoisomers. In addition, some of the compounds of Formula I, Formula II, and Formula III are capable of further forming pharmaceutically acceptable salts and esters. The compounds of this invention may further exist in tautomeric forms and can therefore be produced as individual tautomeric forms or as mixtures of tautomeric forms. Unless indicated otherwise, the description or naming of a compound or groups of compounds is intended to include both the individual isomers or mixtures (racemic or otherwise) of stereoisomers and their tautomeric forms. Methods for the determination of stereochemistry and the separation of stereoisomers are well known to a person of ordinary skill in the art [see the discussion in Chapter 4 of March J.: *Advanced Organic Chemistry*, 4th ed. John Wiley and Sons, New York, NY, 1992]. All of these stereoisomers and pharmaceutical forms are intended to be included within the scope of the present invention.

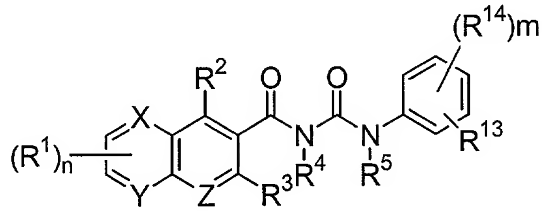
A second embodiment of the present invention provides compounds of Formula Ia, Formula IIa, or Formula IIIa:



Ia



IIa



IIIa

where:

m is an integer of 0 to 4;

n is an integer of 0 to 4 in Formula Ia, and is an integer of 0 to 2 in Formula IIa and Formula IIIa;

X and Y are independently O, S, CH-R^8, or N-R^7 in Formula Ia and Formula IIa, and are independently N and C-R^8 in Formula IIIa;

Z is N or C-R^8;

provided that at least one of X, Y, and Z is a non-carbon ring atom;

each R^1 is independently, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halo(lower alkyl), -CF_3, halogen, nitro, -CN, -OR^9, -SR^9, -NR^9R^{10}, -$NR^9(CH_2)_{1\text{-}6}C(=O)OR^{10}$, -$C(=O)R^9$, -$C(=O)OR^9$, -$C(=O)NR^9R^{10}$, -$OC(=O)R^9$, -$SO_2R^9$, -$OSO_2R^9$, -$SO_2NR^9R^{10}$, -$NR^9SO_2R^{10}$ or -$NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N($C_{1\text{-}2}$ alkyl)$_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted

heterocycloalkyl(lower alkyl), aryl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are -$(CH_2)_{4-6}$- optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1-6}$C(=O)OR (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group, or in Formula I, n=2 and the two R^1's together constitute =O,

R^2, R^3 and R^8 are independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halo(lower alkyl), -CF_3, halogen, nitro, -CN, -OR^9, -SR^9, -NR^9R^{10}, -$NR^9(CH_2)_{1-6}C(=O)OR^{10}$, -$C(=O)R^9$, -$C(=O)OR^9$, -$C(=O)NR^9R^{10}$,-$OC(=O)R^9$, -$SO_2R^9$, -$OSO_2R^9$, -$SO_2NR^9R^{10}$, -$NR^9SO_2R^{10}$ or -$NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N(C_{1-2} alkyl)$_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl(lower alkyl), aryl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are -$(CH_2)_{4-6}$- optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1-6}$C(=O)OR (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group,

each R^7 is independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), halo(lower alkyl), -$C(=O)R^9$, -$C(=O)OR^9$; -$C(=O)NR^9R^{10}$, -SO_2OR^9, -$SO_2NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N(C_{1-2} alkyl)$_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl(lower alkyl), aryl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are -$(CH_2)_{4-6}$- optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1-6}$C(=O)OR (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group,

R^4 and R^5 are independently, hydrogen, lower alkyl optionally substituted lower alkyl, optionally substituted aryl, or optionally substituted aryl(lower alkyl), or, together, are -$(CH_2)_{2-4}$-,

R^{13} is hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), heterocycloalkyl, optionally substituted aryl, optionally substituted aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, $-NR^{15}SO_2R^{16}$ or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, $-CF_3$, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl) or, together, are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or $N-(C_{1-2}$ alkyl) group, and

each R^{14} is independently selected from optionally substituted lower alkyl, optionally substituted aryl, optionally substituted heteroaryl, hydroxy, halogen, $-CF_3$, $-OR^{17}$ $-NR^{17}R^{18}$, $-C(=O)R^{17}$, $-C(=O)OR^{17}$, $-C(=O)NR^{17}R^{18}$, wherein R^{17} and R^{18} are independently, hydrogen, lower alkyl, alkenyl, alkynyl, $-CF_3$, optionally substituted heterocycloalkyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl) or, together, are $-(CH_2)_{4-6}-$, optionally interrupted by one O, S, NH or $N-(C_{1-2}$ alkyl) group,

or a pharmaceutically acceptable salt thereof, optionally in the form of a single stereoisomer or mixture of stereoisomers thereof.

Preferred compounds of the second embodiment are:

1. compounds of Formula Ia, where X and Y are O, Z is C-H, and n=0.
2. compounds of Formula Ia, where X and Y are O, Z is C-H, and each R^1 is lower alkyl.
3. compounds of Formula Ia, where X is O, Y is $N-R^7$, where R^7 is hydrogen or lower alkyl, Z is C-H, and each R^1 is lower alkyl.
4. compounds of Formula Ia, where X is $N-R^7$, where R^7 is hydrogen or lower alkyl, Y is O, Z is C-H, and each R^1 is lower alkyl.
5. compounds of Formula Ia, where X and Y are each $N-R^7$, where R^7 is hydrogen, lower alkyl, substituted lower alkyl, or optionally substituted aryl(lower alkyl), Z is C-H, and each R^1 is lower alkyl.

6. compounds of Formula IIIa, where X and Y are N, Z is C-H, and n=0.
7. compounds of Formula IIIa, where X and Y are N, Z is C-H, and each R^1 is lower alkyl.
8. compounds of the second embodiment where R^2 and R^3 are independently selected from hydrogen, lower alkyl or halogen.
9. compounds of the second embodiment where R^4 and R^5 are independently selected from hydrogen or lower alkyl.
10. compounds of the second embodiment, where R^{13} is independently selected from aryl, substituted aryl, -heteroaryl or optionally substituted heteroaryl, halogen, $-CF_3$, -CN, $-OR^{15}$, or $-CO_2R^{15}$, wherein R^{15} is hydrogen, lower alkyl or optionally substituted aryl.
11. compounds of the second embodiment, where each R^{14} is independently selected from halogen, $-CF_3$, $-OR^{17}$, $-CO_2R^{17}$, or $-OCH_2CO_2R^{17}$, wherein R^{17} is hydrogen, lower alkyl or optionally substituted aryl.

A third embodiment of the present invention provides pharmaceutical compositions comprising a pharmaceutically acceptable excipient and a therapeutically effective amount of at least one compound of this invention.

A fourth embodiment of the present invention provides methods for treating a disease treatable by the administration of an MCP-1 inhibitor, for example, chronic or acute inflammatory or autoimmune diseases such as asthma, atherosclerosis, diabetic nephropathy, glomerulonephritis, inflammatory bowel disease, Crohn's disease, multiple sclerosis, pancreatitis, pulmonary fibrosis, psoriasis, restenosis, rheumatoid arthritis, or transplant rejection, in a mammal in need thereof, comprising the administration to such mammal of a therapeutically effective amount of at least one compound of this invention or a pharmaceutically acceptable salt thereof or a pharmaceutical composition comprising the same.

A fifth embodiment of this invention provides a process for the preparation of the compounds of the invention or pharmaceutically acceptable salts thereof.

DETAILED DESCRIPTION OF THE INVENTION

Definitions

The following definitions apply to the description of compounds of the present invention:

"Alkyl" is a linear or branched saturated hydrocarbon radical having from 1 to 20 carbon atoms. Examples of alkyl radicals are: methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, n-pentyl, n-hexyl, dodecyl, etc.

"Lower alkyl", as in "lower alkyl," "lower alkoxy," "cycloalkyl(lower alkyl)," "aryl(lower alkyl)", or "heteroaryl(lower alkyl)", means a C_{1-10} alkyl radical. Preferred lower alkyl radicals are those having from 1 to 6 carbon atoms.

"Alkenyl" is a linear or branched hydrocarbon radical having from 2 to 20 carbon atoms and at least one carbon-carbon double bond. Examples of alkenyl radicals are: vinyl, 1-propenyl, isobutenyl, etc.

"Alkynyl" is a linear or branched hydrocarbon radical having from 2 to 20 carbon atoms and at least one carbon-carbon triple bond. Examples of alkynyl radicals are: propargyl, 1-butynyl, etc.

"Cycloalkyl" is a monovalent cyclic hydrocarbon radical having from 3 to 12 carbon atoms. Examples of cycloalkyl radicals are: cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, etc.

"Substituted cycloalkyl" is a monovalent cyclic hydrocarbon radical having from 3 to 12 carbon atoms, which is substituted with one, two, or three substituents each independently selected from aryl, substituted aryl, heteroaryl, halogen, $-CF_3$, nitro, -CN, -OR, -SR, -NRR′, -C(=O)R, -OC(=O)R, -C(=O)OR, $-SO_2OR$, $-OSO_2R$, $-SO_2NRR'$, $-NRSO_2R'$, -C(=O)NRR′, -NRC(=O)R′ or $-PO_3HR$, wherein R and R′ are, independently, hydrogen, lower alkyl, cycloalkyl, aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), heteroaryl, or heteroaryl(lower alkyl), and having 3 to 12 ring atoms, 1 to 5 of which are heteroatoms chosen, independently, from N, O, or S, and includes monocyclic, condensed heterocyclic, and condensed carbocyclic and heterocyclic rings (*e.g.*, piperidyl, 4-morpholyl, 4-piperazinyl, pyrrolidinyl, perhydropyrrolizinyl, 1,4-diazaperhydroepinyl, etc.).

"Cycloalkyl(lower alkyl)" is a lower alkyl radical which is substituted with a cycloalkyl, as previously defined. Examples of cycloalkyl(lower alkyl) radicals are cyclopropylmethyl, cyclobutylethyl, cyclopentylmethyl, cyclohexylmethyl, etc.

"Heterocycloalkyl" is a monovalent cyclic hydrocarbon radical having 3 to 12 carbon ring atoms, 1 to 5 of which are heteroatoms chosen, independently, from N, O, or S, and includes monocyclic, condensed heterocyclic, and condensed carbocyclic and heterocyclic rings (*e.g.*, piperidyl, 4-morpholyl, 4-piperazinyl, pyrrolidinyl, perhydropyrrolizinyl, 1,4-diazaperhydro-epinyl, etc.).

"Substituted heterocycloalkyl" is a monovalent cyclic hydrocarbon radical having from 3 to 12 carbon atoms, which is substituted with one, two, or three substituents each independently selected from aryl, substituted aryl, heteroaryl, halogen, -CF_3, nitro, -CN, -OR, -SR, -NRR′, -C(=O)R, -OC(=O)R, -C(=O)OR, -SO_2OR, -OSO_2R, -SO_2NRR′, -$NRSO_2$R′, -C(=O)NRR′, -NRC(=O)R′ or -PO_3HR, wherein R and R′ are, independently, hydrogen, lower alkyl, cycloalkyl, aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), heteroaryl, or heteroaryl(lower alkyl), and having 3 to 12 ring atoms, 1 to 5 of which are heteroatoms chosen, independently, from N, O, or S, and includes monocyclic, condensed heterocyclic, and condensed carbocyclic and heterocyclic rings (*e.g.*, piperidyl, 4-morpholyl, 4-piperazinyl, pyrrolidinyl, perhydropyrrolizinyl, 1,4-diazaperhydroepinyl, etc.).

"Substituted heterocycloalkyl(lower alkyl)" is a lower alkyl radical which is substituted with a monovalent cyclic hydrocarbon radical having from 3 to 12 carbon atoms, which is substituted with one, two, or three substituents each independently selected from aryl, substituted aryl, heteroaryl, halogen, -CF_3, nitro, -CN, -OR, -SR, -NRR′, -C(=O)R, -OC(=O)R, -C(=O)OR, -SO_2OR, -OSO_2R, -SO_2NRR′, -$NRSO_2$R′, -C(=O)NRR′, -NRC(=O)R′ or -PO_3HR, wherein R and R′ are, independently, hydrogen, lower alkyl, cycloalkyl, aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), heteroaryl, or heteroaryl(lower alkyl), and having 3 to 12 ring atoms, 1 to 5 of which are heteroatoms chosen, independently, from N, O, or S, and includes monocyclic, condensed heterocyclic, and condensed carbocyclic and heterocyclic rings (*e.g.*, piperidyl, 4-morpholyl, 4-piperazinyl, pyrrolidinyl, perhydropyrrolizinyl, 1,4-diazaperhydro-epinyl, etc.).

"Substituted alkyl" or "substituted lower alkyl," is an alkyl or lower alkyl radical, respectively, which is substituted with one, two, or three substituents each independently selected from aryl, substituted aryl, heteroaryl, halogen, $-CF_3$, nitro, -CN, -OR, -SR, -NRR′, -C(=O)R, -OC(=O)R, -C(=O)OR, $-SO_2OR$, $-OSO_2R$, $-SO_2NRR'$, $-NRSO_2R'$, -C(=O)NRR′, -NRC(=O)R′ or $-PO_3HR$, wherein R and R′ are, independently, hydrogen, lower alkyl, cycloalkyl, aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), heteroaryl, or heteroaryl(lower alkyl).

"Halo(lower alkyl)" is a radical derived from lower alkyl containing at least one halogen substituent. Non-limiting examples of halo-lower alkyl radicals include: $-CF_3$, $-C_2F_5$, etc.

"Aryl", as in "aryl", "aryloxy", and "aryl(lower alkyl)", is a radical derived from an aromatic hydrocarbon containing 6 to 16 ring carbon atoms, having a single ring (*e.g.*, phenyl), or two or more condensed rings, preferably 2 to 3 condensed rings (*e.g.*, naphthyl), or two or more aromatic rings, preferably 2 to 3 aromatic rings, which are linked by a single bond (*e.g.*, biphenyl). Preferred aryl radicals are those containing from 6 to 14 carbon atoms.

"Substituted aryl" is an aryl radical which is substituted with one, two, or three substituents each independently selected from alkyl, substituted alkyl, halo(lower alkyl), halogen, nitro, -CN, -OR, -SR, -NRR′, -C(=O)R, -OC(=O)R, -C(=O)OR, $-SO_2OR$, $-OSO_2R$, $-SO_2NRR'$, $-PO_3H_2$, $-NRSO_2R'$, -C(=O)NRR′, or NRC(=O)R′, wherein R and R′ are, independently, hydrogen, lower alkyl, substituted lower alkyl, cycloalkyl, aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), heteroaryl, or heteroaryl(lower alkyl). Preferred substituted aryl radicals are those substituted with one, two, or three substituents each independently selected from the group consisting of lower alkyl, halogen, $-CF_3$, nitro, -CN, -OR, -NRR′, C(=O)NRR′, $-SO_2OR$, $-SO_2NRR'$, $-PO_3H_2$, $-NRSO_2R'$, or -NRC(=O)R′.

"Heteroaryl", as in "heteroaryl" and "heteroaryl(lower alkyl)", is a radical derived from an aromatic hydrocarbon containing 5 to 14 ring atoms, 1 to 5 of which are heteroatoms chosen, independently, from N, O, or S, and includes monocyclic, condensed heterocyclic, and condensed carbocyclic and heterocyclic aromatic rings (*e.g.*, thienyl, furyl, pyrrolyl, pyrimidinyl, isoxazolyl, oxazolyl, indolyl, isobenzofuranyl, purinyl, isoquinolyl, pteridinyl, imidazolyl, pyridyl, pyrazolyl, pyrazinyl, quinolyl, etc.).

"Substituted heteroaryl" is a heteroaryl radical which is substituted with one, two, or three substituents each independently selected from alkyl, substituted alkyl, halogen, $-CF_3$, nitro, -CN, -OR, -SR, -NRR′, -C(=O)R, OC(=O)R, -C(=O)OR, $-SO_2OR$, $-OSO_2R$, $-SO_2NRR'$, $-NRSO_2R'$, -C(=O)NRR′, or -NRC(=O)R′, wherein R and R′ are, independently, hydrogen, lower alkyl, substituted lower alkyl, cycloalkyl, aryl, substituted aryl, aryl(lower alkyl), substituted aryl(lower alkyl), heteroaryl, or heteroaryl(lower alkyl). Particularly preferred substituents on the substituted heteroaryl moiety include lower alkyl, substituted lower alkyl, halo-lower-alkyl, halogen, nitro, -CN, -OR, -SR, and -NRR′.

"Aryl(lower alkyl)" is a lower alkyl radical which is substituted with an aryl, as previously defined.

"Substituted aryl(lower alkyl)" is an aryl(lower alkyl) radical having one to three substituents on either or both of the aryl and the alkyl portion of the radical.

"Heteroaryl(lower alkyl)" is a lower alkyl radical which is substituted with a heteroaryl, as previously defined.

"Substituted heteroaryl(lower alkyl)" is a heteroaryl(lower alkyl) radical having one to three substituents on the heteroaryl portion or the alkyl portion of the radical, or both.

"Lower alkoxy" is an -OR radical, where R is a lower alkyl or cycloalkyl.

"Halogen" means fluoro, chloro, bromo, or iodo.

"Tautomers" are isomeric compounds that differ from one another by interchanged positions of σ and π bonds. The compounds are in equilibrium with one another. They may also differ from one another in the position at which a hydrogen atom is attached.

"Inner salts" or "Zwitterions" are compounds wherein the positive and negative groups, such as amine and acid groups within the compound, are equally ionized. The compounds are charge separated species that result from the transfer of a proton from the acidic site to a basic site, typically in a compound containing an amine and an acid group.

"Pharmaceutically acceptable excipient" means an excipient that is useful in preparing a pharmaceutical composition that is generally safe, non-toxic, and desirable, and includes excipients that are acceptable for veterinary use as well as for human pharmaceutical use. Such excipients may be solid, liquid, semisolid, or, in the case of an aerosol composition, gaseous.

"Pharmaceutically acceptable salts and esters" means any salt and ester that is pharmaceutically acceptable and has the desired pharmacological properties. Such salts include salts that may be derived from an inorganic or organic acid, or an inorganic or organic base, including amino acids, which is not toxic or undesirable in any way. Suitable inorganic salts include those formed with the alkali metals, *e.g.*, sodium and potassium, magnesium, calcium, and aluminum. Suitable organic salts include those formed with organic bases such as the amine bases, *e.g.*, ethanolamine, diethanolamine, triethanolamine, tromethamine, *N*-methylglucamine, and the like. Such salts also include acid addition salts formed with inorganic acids (*e.g.*, hydrochloric and hydrobromic acids) and organic acids (*e.g.*, acetic acid, citric acid, maleic acid, and the alkane and arene-sulfonic acids such as methanesulfonic acid and benzenesulfonic acid). Pharmaceutically acceptable esters include esters formed from carboxy, sulfonyloxy, and phosphonoxy groups present in the compounds, *e.g.*, C1-6 alkyl esters. When there are two acidic groups present, a pharmaceutically acceptable salt or ester may be a mono-acid-mono-salt or ester or a di-salt or ester; and similarly, where there are more than two acidic groups present, some or all of such groups can be salified or esterified.

"Therapeutically effective amount" means that amount which, when administered to a mammal for treating a disease, is sufficient to effect such treatment for the disease.

"Treating" or "treatment" of a disease in a mammal includes:

(1) Preventing the disease from occurring in a mammal which may be predisposed to the disease but does not yet experience or display symptoms of the disease;

(2) Inhibiting the disease, *i.e.*, arresting its development, or

(3) Relieving the disease, *i.e.*, causing regression of the disease.

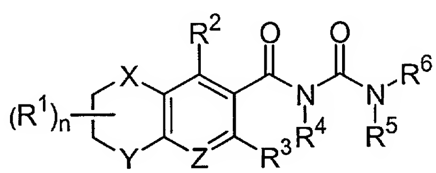
"Disease" includes any unhealthy condition of an animal (which includes human and non-human mammals), including particularly various forms of inflammatory illnesses or diseases, such as asthma, atherosclerosis, diabetic nephropathy, glomerulonephritis, inflammatory bowel disease, Crohn's disease, multiple sclerosis, pancreatitis, pulmonary fibrosis, psoriasis, restenosis, rheumatoid arthritis, immune disorders, and transplant rejection.

The compounds of this invention may possess one or more chiral centers, and can therefore be produced as individual stereoisomers or as mixtures of stereoisomers, depending on whether individual stereoisomers or mixtures of stereoisomers of the starting materials are used.

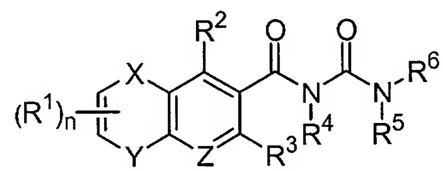
Unless indicated otherwise, the description or naming of a compound or groups of compounds is intended to include both the individual isomers or mixtures (racemic or otherwise) of stereoisomers. Methods for the determination of stereochemistry and the separation of stereoisomers are well known to a person of ordinary skill in the art [see the discussion in Chapter 4 of March J.: *Advanced Organic Chemistry*, 4th ed. John Wiley and Sons, New York, NY, 1992].

Compounds and Pharmaceutically Acceptable Salts

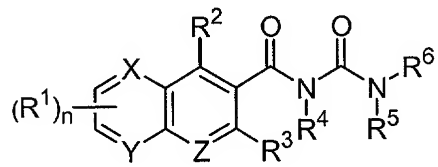
A first embodiment of the present invention provides compounds of Formula I, Formula II, and Formula III:



I



II



III

where n, X, Y, Z and R^1 to R^8 are as defined in the Summary of the Invention.

Where R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), $N-(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group, examples include piperazinyl, 4-methylpiperazinyl, 4-morpholyl, and hexahydropyrimidyl.

Preferably, X and Y are independently O or N-R^7 in Formula I and Formula II.

Preferably, R^1 is optionally substituted lower alkyl, optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halogen, $-OR^9$, $-NR^9R^{10}$, $-C(=O)OR^9$, $-C(=O)NR^9R^{10}$, $-SO_2NR^9R^{10}$, or $-NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-$N(C_{1-2}\ alkyl)_2$, lower alkyl(optionally

substituted heterocycloalkyl), aryl(lower alkyl), optionally substituted aryl, heteroaryl, or heteroaryl(lower alkyl).

More preferably, n is 0.

Preferably, R^2 is hydrogen, optionally substituted lower alkyl, cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halogen, $-OR^9$, $-NR^9(CH_2)_{1-6}C(=O)OR^{10}$, $-C(=O)OR^9$, $-C(=O)NR^9R^{10}$, $-SO_2NR^9R^{10}$, or $-NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-$N(C_{1-2}$ alkyl$)_2$, lower alkyl(optionally substituted heterocycloalkyl), optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), $N-(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group.

More preferably, R^2 is optionally substituted lower alkyl, cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halogen, $-OR^9$, $-NR^9(CH_2)_{1-6}C(=O)OR^{10}$, $-C(=O)OR^9$, $-C(=O)NR^9R^{10}$, $-SO_2NR^9R^{10}$, or $-NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-$N(C_{1-2}$ alkyl$)_2$, lower alkyl(optionally substituted heterocycloalkyl), optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), $N-(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group.

Preferably, R^3 is hydrogen, optionally substituted lower alkyl, optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halo(lower alkyl), halogen, $-OR^9$, $-NR^9R^{10}$, $-C(=O)OR^9$, or $-C(=O)NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-$N(C_{1-2}$ alkyl$)_2$, lower alkyl(optionally substituted heterocycloalkyl), optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S,

NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1\text{-}6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted $C_{1\text{-}2}$ alkyl) group.

More preferably, R^3 is optionally substituted lower alkyl, optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halo(lower alkyl), halogen, $-OR^9$, $-NR^9R^{10}$, $-C(=O)OR^9$, or $-C(=O)NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N$(C_{1\text{-}2}$ alkyl$)_2$, lower alkyl(optionally substituted heterocycloalkyl), optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4\text{-}6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1\text{-}6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted $C_{1\text{-}2}$ alkyl) group.

Preferably, each R^7 is independently, hydrogen, optionally substituted lower alkyl, optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), $-C(=O)R^9$, $-C(=O)OR^9$, $-C(=O)NR^9R^{10}$, $-SO_2R^9$, or $-SO_2NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N$(C_{1\text{-}2}$ alkyl$)_2$, alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, or heteroaryl(lower alkyl).

Preferably, R^8 is hydrogen, optionally substituted lower alkyl, optionally substituted heterocycloalkyl, optionally substituted aryl, optionally substituted heteroaryl, optionally substituted aryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, $-OR^9$, $-NR^9R^{10}$, $-C(=O)R^9$, $-C(=O)OR^9$, $-C(=O)NR^9R^{10}$, $-OC(=O)R^9$, $-SO_2R^9$, $-SO_2NR^9R^{10}$, $-NR^9SO_2R^{10}$ or $-NR^9C(=O)R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N$(C_{1\text{-}2}$ alkyl$)_2$, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4\text{-}6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1\text{-}6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted $C_{1\text{-}2}$ alkyl) group.

Preferably, R^4 and R^5 are independently, hydrogen or lower alkyl, or together are $-(CH_2)_{2\text{-}4}-$. More preferably, R^4 and R^5 are independently, hydrogen or lower alkyl.

Preferably, R^6 is hydrogen, optionally substituted lower alkyl, alkenyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl,

optionally substituted aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), $-C(=O)R^{11}$, $-C(=O)OR^{11}$, $-C(=O)NR^{11}R^{12}$, $-SO_2R^{11}$, or $-SO_2NR^{11}R^{12}$, wherein R^{11} and R^{12} are independently, hydrogen, optionally substituted lower alkyl, cycloalkyl, cycloalkyl(lower alkyl), aryl, heteroaryl, heteroaryl(lower alkyl), or R^{11} and R^{12} together are $-(CH_2)_{4-6}-$.

A particular preferred "substituted aryl" is a phenyl group substituted with a R^{13} and optionally substituted with up to four R^{14}s, where R^{13} and R^{14} are defined with respect to Formulae Ia, IIa, and IIIa.

The above-listed preferences equally apply for the compounds of Formulae Ia, IIa and IIIa, below.

In a more preferred version of the first embodiment of the invention,

Y is N-R^7 and Z is C-R^8 for Formulae I and II,

R^1 is lower alkyl,

R^4 and R^5 are hydrogen, and

R^6 is hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl, aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-C(=O)R^{11}$, $-C(=O)OR^{11}$, $-C(=O)NR^{11}R^{12}$, $-SO_2R^{11}$, or $-SO_2NR^{11}R^{12}$, wherein R^{11} and R^{12} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^{11} and R^{12} together are $-(CH_2)_{4-6}-$,

or a pharmaceutically acceptable salt thereof, optionally in the form of a single stereoisomer or mixture of stereoisomers thereof.

More preferably still, R^2 is $-NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N(C_{1-2} alkyl)$_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), benzyl, optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group.

In another more preferred version of the first embodiment of the invention,

Y is N-R^7 and Z is C-R^8 in Formuale I and II,

R^1 and R^8 are lower alkyl,

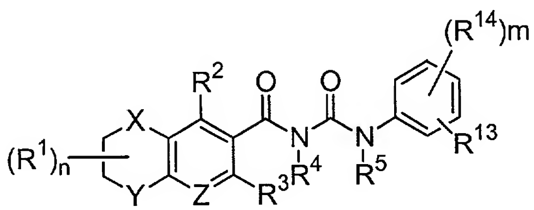
R^2 is $-NR^9R^{10}$,

R^4 and R^5 are hydrogen, and

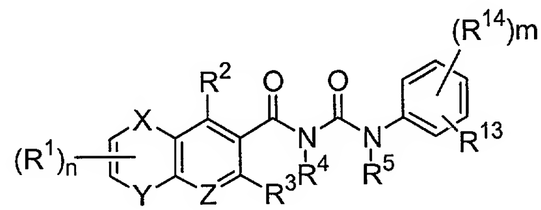
R^6 is hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted heterocycloalkyl, optionally substituted aryl, aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-C(=O)R^{11}$, $-C(=O)OR^{11}$, $-C(=O)NR^{11}R^{12}$, $-SO_2R^{11}$, or $-SO_2NR^{11}R^{12}$, wherein R^{11} and R^{12} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^{11} and R^{12} together are $-(CH_2)_{4-6}-$,

or a pharmaceutically or a pharmaceutically acceptable salt thereof, optionally in the form of a single stereoisomer or mixture of stereoisomers thereof.

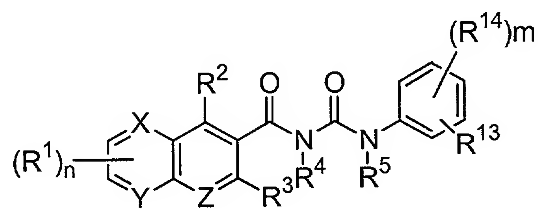
The second embodiment of the present invention provides compounds of Formulae Ia, IIa or IIIa:



Ia



IIa



IIIa

wherein:

Y is O, S or N-R^7 in Formulae Ia and IIa,

X and Y are independently N and C-R^7 in Formula IIIa,

Z is N or C-R^8,

R^1, R^2, R^3, R^4, R^5, R^7 and R^8 are as defined in the first embodiment,

R^{13} is hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), heterocycloalkyl, optionally substituted aryl, optionally substituted aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, $-NR^{15}SO_2R^{16}$ or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, $-CF_3$, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), or, together, are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group, and

each R^{14} is independently selected from optionally substituted lower alkyl, optionally substituted aryl, optionally substituted heteroaryl, hydroxy, halogen, $-CF_3$, $-OR^{17}$ $-NR^{17}R^{18}$, $-C(=O)R^{17}$, $-C(=O)OR^{17}$, $-C(=O)NR^{17}R^{18}$, wherein R^{17} and R^{18} are independently, hydrogen, lower alkyl, alkenyl, alkynyl, $-CF_3$, optionally substituted heterocycloalkyl, cycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or, together, are $-(CH_2)_{4-6}-$, optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group,

or a pharmaceutically acceptable salt thereof as a single stereoisomer or mixture of stereoisomers.

Wherein R^{13} is $-OR^{15}$, and R^{15} is optionally substituted lower alkyl, where it may, for example, be optionally substituted with $-C(=O)OR^{19}$, wherein R^{19} is hydrogen or lower alkyl.

Where R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group, examples include piperazinyl, 4-methylpiperazinyl, morpholyl, and hexahydropyrimidyl.

n is a stereocompatible integer of 0 to 4. The term "stereocompatible" limits the number of substituents permissible by available valences in accordance with space requirements of substituents, among other.

Preferably, R^{13} is hydrogen, optionally substituted lower alkyl, alkenyl, heterocycloalkyl, optionally substituted aryl, optionally substituted aryl(lower alkyl), optionally substituted

heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl) or, together, are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group.

More preferably, R^{13} is optionally substituted lower alkyl, alkenyl, heterocycloalkyl, optionally substituted aryl, optionally substituted aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl) or, together, are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group.

Preferably, R^{14} is independently selected from optionally substituted lower alkyl, optionally substituted aryl, optionally substituted heteroaryl, hydroxy, halogen, $-CF_3$, $-OR^{17}$, $-NR^{17}R^{18}$, $-C(=O)R^{17}$, $-C(=O)OR^{17}$, $-C(=O)NR^{17}R^{18}$, wherein R^{17} and R^{18} are, independently, hydrogen, lower alkyl, alkenyl, or optionally substituted aryl.

Preferably, where R^{13} is not hydrogen, n is an integer of 1 to 2. More preferably, where R^{13} is not hydrogen, n is 1.

In another more preferred version of the second embodiment of the invention,

Y is N-R^7 and Z is C-R^8 for Formulae Ia and IIa,

R^1 is lower alkyl,

R^2 is $-NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N(C_{1-2} alkyl)$_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), benzyl, optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), $N-(CH_2)_{1-6}C(=O)OR$

(where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group such as piperazinyl, 4-methylpiperazinyl, 4-morpholyl, hexahydropyrimidyl, and

R^{13} is hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), heterocycloalkyl, optionally substituted aryl, aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, $-NR^{15}SO_2R^{16}$ or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, lower alkyl, alkenyl, alkynyl, $-CF_3$, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl) or R^{15} and R^{16} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group.

More preferably still, R^4 and R^5 are hydrogen.

A particular preferred "substituted aryl" is a phenyl group substituted with a R^{13} and optionally substituted with up to four R^{14}s, where R^{13} and R^{14} are defined with respect to Formulae Ia, IIa and IIIa.

Wherein R^{13} is $-OR^{15}$, and R^{15} is optionally substituted lower alkyl, it may, for example, be optionally substituted with $-C(=O)OR^{19}$, wherein R^{19} is hydrogen or lower alkyl.

Where R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group, examples include piperazinyl, 4-methylpiperazinyl, morpholyl, and hexahydropyrimidyl.

m is a stereocompatible integer of 0 to 4. The term "stereocompatible" limits the number of substituents permissible by available valences in accordance with space requirements of substituents, among other.

Preferably, R^{13} is hydrogen, optionally substituted lower alkyl, alkenyl, heterocycloalkyl, optionally substituted aryl, optionally substituted aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally

substituted heteroaryl(lower alkyl) or, together, are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group.

More preferably, R^{13} is optionally substituted lower alkyl, alkenyl, heterocycloalkyl, optionally substituted aryl, optionally substituted aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, optionally substituted lower alkyl, alkenyl, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl) or, together, are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group.

Preferably, R^{14} is independently selected from optionally substituted lower alkyl, optionally substituted aryl, optionally substituted heteroaryl, hydroxy, halogen, $-CF_3$, $-OR^{17}$, $-NR^{17}R^{18}$, $-C(=O)R^{17}$, $-C(=O)OR^{17}$, $-C(=O)NR^{17}R^{18}$, wherein R^{17} and R^{18} are, independently, hydrogen, lower alkyl, alkenyl, or optionally substituted aryl.

Preferably, where R^{13} is not hydrogen, m is an integer of 1 to 2. More preferably, where R^{13} is not hydrogen, m is 1.

In another more preferred version of the second embodiment of the invention,

Z is C-R^8

R^1 is lower alkyl,

R^2 is $-NR^9R^{10}$, wherein R^9 and R^{10} are independently, hydrogen, optionally substituted lower alkyl, lower alkyl-N(C_{1-2} alkyl)$_2$, lower alkyl(optionally substituted heterocycloalkyl), alkenyl, alkynyl, optionally substituted cycloalkyl, cycloalkyl(lower alkyl), benzyl, optionally substituted aryl, heteroaryl, heteroaryl(lower alkyl), or R^9 and R^{10} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH, N-(aryl), N-(aryl(lower alkyl)), N-$(CH_2)_{1-6}C(=O)OR$ (where R is hydrogen or lower alkyl) or N-(optionally substituted C_{1-2} alkyl) group such as piperazinyl, 4-methylpiperazinyl, 4-morpholyl, hexahydropyrimidyl, and

R^{13} is hydrogen, optionally substituted lower alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkyl(lower alkyl), heterocycloalkyl, optionally substituted aryl, aryl(lower alkyl), optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl), halo(lower

alkyl), $-CF_3$, halogen, nitro, -CN, $-OR^{15}$, $-SR^{15}$, $-NR^{15}R^{16}$, $-C(=O)R^{15}$, $-C(=O)OR^{15}$, $-C(=O)NR^{15}R^{16}$, $-OC(=O)R^{15}$, $-SO_2R^{15}$, $-SO_2NR^{15}R^{16}$, $-NR^{15}SO_2R^{16}$ or $-NR^{15}C(=O)R^{16}$, wherein R^{15} and R^{16} are independently, hydrogen, lower alkyl, alkenyl, alkynyl, $-CF_3$, cycloalkyl, optionally substituted heterocycloalkyl, cycloalkyl(lower alkyl), optionally substituted aryl, optionally substituted heteroaryl, optionally substituted heteroaryl(lower alkyl) or R^{15} and R^{16} together are $-(CH_2)_{4-6}-$ optionally interrupted by one O, S, NH or N-(C_{1-2} alkyl) group.

The above-listed preferences for the compounds of Formulae I, II, and III equally apply for the compounds of Formulae Ia, IIa and IIIa.

In addition, certain compounds of the invention may contain one or more chiral centers. In such cases, all stereoisomers also fall within the scope of this invention. The invention compounds include the individually isolated stereoisomers as well as mixtures of such stereoisomers.

Some of the compounds of Formula I, Formula II, and Formula III are capable of further forming pharmaceutically acceptable salts and esters. All of these forms are included within the scope of the present invention.

Pharmaceutically acceptable base addition salts of the compounds of Formula I, Formula II, and Formula III include salts which may be formed when acidic protons present in the parent compound are capable of reacting with inorganic or organic bases. Typically, the parent compound is treated with an excess of an alkaline reagent, such as hydroxide, carbonate or alkoxide, containing an appropriate cation. Cations such as Na^+, K^+, Ca^{2+} and NH_4^+ are examples of cations present in pharmaceutically acceptable salts. The Na^+ salts are especially useful. Acceptable inorganic bases, therefore, include aluminum hydroxide, calcium hydroxide, potassium hydroxide, sodium carbonate and sodium hydroxide. Salts may also be prepared using organic bases, such as choline, dicyclohexylamine, ethylenediamine, ethanolamine, diethanolamine, triethanolamine, procaine, *N*-methylglucamine and the like [for a nonexclusive list see, for example, Berge et al., "Pharmaceutical Salts," *J. Pharma. Sci.* 66:1 (1977)]. The free acid form may be regenerated by contacting the base addition salt with an acid and isolating the free acid in the conventional manner. The free acid forms can differ from their respective salt forms somewhat in certain physical properties such as solubility in polar solvents.

Pharmaceutically acceptable acid addition salts of the compounds of Formula I, Formula II, and Formula III include salts which may be formed when the parent compound contains a basic group. Acid addition salts of the compounds are prepared in a suitable solvent from the parent compound and an excess of a non-toxic inorganic acid, such as hydrochloric acid, hydrobromic acid, sulfuric acid (giving the sulfate and bisulfate salts), nitric acid, phosphoric acid and the like, or a non-toxic organic acid such as acetic acid, propionic acid, glycolic acid, pyruvic acid, oxalic acid, malic acid, malonic acid, succinic acid, maleic acid, fumaric acid, tartaric acid, citric acid, benzoic acid, cinnamic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, salicylic acid, *p*-toluenesulfonic acid, hexanoic acid, heptanoic acid, cyclopentanepropionic acid, lactic acid, *o*-(4-hydroxy-benzoyl)benzoic acid, 1,2-ethanedisulfonic acid, 2-hydroxyethanesulfonic acid, benzenesulfonic acid, *p*-chlorobenzenesulfonic acid, 2-naphthalenesulfonic acid, camphorsulfonic acid, 4-methylbicyclo[2.2.2.]oct-2-ene-1-carboxylic acid, glucoheptonic acid, gluconic acid, 4,4'-methylenebis(3-hydroxy-2-naphthoic) acid, 3-phenylpropionic acid, trimethylacetic acid, *tert*-butylacetic acid, laurylsulfuric acid, glucuronic acid, glutamic acid, 3-hydroxy-2-naphthoic acid, stearic acid, muconic acid and the like. The free base form may be regenerated by contacting the acid addition salt with a base and isolating the free base in the conventional manner. The free base forms can differ from their respective salt forms somewhat in certain physical properties such as solubility in polar solvents.

Also included in the embodiment of the present invention are salts of amino acids such as arginate and the like, gluconate, and galacturonate [see Berge, *supra* (1977)].

Some of the compounds of the invention may form inner salts or Zwitterions.

Certain of the compounds of the present invention can exist in unsolvated forms as well as solvated forms, including hydrated forms, and are intended to be encompassed within the scope of the present invention.

Certain of the compounds of the present invention may also exist in one or more solid or crystalline phases or polymorphs; the variable biological activities of such polymorphs or mixtures of such polymorphs are also included in the scope of this invention.

Some preferred compounds of the present invention are those listed in Table 11.

Pharmaceutical Compositions

A third embodiment of the present invention provides pharmaceutical compositions comprising a pharmaceutically acceptable excipient and a therapeutically effective amount of at least one compound of this invention.

Pharmaceutical compositions of the compounds of this invention, or derivatives thereof, may be formulated as solutions or lyophilized powders for parenteral administration. Powders may be reconstituted by addition of a suitable diluent or other pharmaceutically acceptable carrier prior to use. The liquid formulation is generally a buffered, isotonic, aqueous solution. Examples of suitable diluents are normal isotonic saline solution, 5% dextrose in water or buffered sodium or ammonium acetate solution. Such formulations are especially suitable for parenteral administration, but may also be used for oral administration. It may be desirable to add excipients such as polyvinylpyrrolidinone, gelatin, hydroxycellulose, acacia, polyethylene glycol, mannitol, sodium chloride or sodium citrate.

Alternatively, these compounds may be encapsulated, tableted or prepared in an emulsion or syrup for oral administration. Pharmaceutically acceptable solid or liquid carriers may be added to enhance or stabilize the composition, or to facilitate preparation of the composition. Liquid carriers include syrup, peanut oil, olive oil, glycerin, saline, alcohols and water. Solid carriers include starch, lactose, calcium sulfate, dihydrate, terra alba, magnesium stearate or stearic acid, talc, pectin, acacia, agar or gelatin. The carrier may also include a sustained release material such as glyceryl monostearate or glyceryl distearate, alone or with a wax. The amount of solid carrier varies but, preferably, will be between about 20 mg to about 1 g per dosage unit.

The pharmaceutical preparations are made following the conventional techniques of pharmacy involving milling, mixing, granulation, and compressing, when necessary, for tablet forms; or milling, mixing and filling for hard gelatin capsule forms. When a liquid carrier is used, the preparation will be in the form of a syrup, elixir, emulsion or an aqueous or non-aqueous suspension. Such a liquid formulation may be administered directly p.o. or filled into a soft gelatin capsule.

Some specific examples of suitable pharmaceutical compositions are described in the examples.

Typically, a pharmaceutical composition of the present invention is packaged in a container with a label indicating the use of the pharmaceutical composition in the treatment of a disease such as asthma, atherosclerosis, glomerulonephritis, pancreatitis, restenosis, rheumatoid arthritis, multiple sclerosis, diabetic nephropathy, pulmonary fibrosis, and transplant rejection, or a chronic or acute immune disorder, or a combination of any of these disease conditions.

Methods of Use

A fourth embodiment of the present invention provides a method for treating a disease treatable by administration of an MCP-1 inhibitor, for example, a chronic or acute inflammatory disease such as asthma, atherosclerosis, diabetic nephropathy, glomerulonephritis, inflammatory bowel disease, Crohn's disease, multiple sclerosis, pancreatitis, pulmonary fibrosis, psoriasis, restenosis, rheumatoid arthritis, or a chronic or acute immune disorder, or transplant rejection in a mammal in need thereof, comprising the administration to such mammal of a therapeutically effective amount of at least one compound of general Formula I, Formula II and Formula III or pharmaceutically acceptable salts and esters thereof.

The compounds of the present invention inhibit chemotaxis of a human monocytic cell line (THP-1 cells) induced by human MCP-1 *in vitro*. This inhibitory effect has also been observed *in vivo*. Indeed, the compounds have been shown to reduce monocyte infiltration in a thioglycollate-induced inflammation model in mice.

The compounds of the present invention have been found to prevent the onset or ameliorate symptoms in several animal models of inflammation. For example, the compounds inhibited recruitment of monocytes into the glomeruli in an anti-Thy-1 antibody-induced model of nephritis; reduced paw swelling in a rat model of adjuvant arthritis; inhibited neointimal hyperplasia after balloon injury in a rat model of restenosis, and reduced the amount of lesion of the aortic sinus in an apoE-deficient mouse model of atherosclerosis.

The ability of the compounds of this invention to block the migration of monocytes and prevent or ameliorate inflammation, which is demonstrated in the specific examples, indicates their usefulness in the treatment and management of disease states associated with aberrant leukocyte recruitment.

The use of the compounds of the invention for treating inflammatory and autoimmune disease by combination therapy may also comprise the administration of the compound of the invention to a mammal in combination with common anti-inflammatory drugs, cytokines, or immunomodulators.

The compounds of this invention are thus used to inhibit leukocyte migration in patients which require such treatment. The method of treatment comprises the administration, orally or parenterally, of an effective quantity of the chosen compound of the invention, preferably dispersed in a pharmaceutical carrier. Dosage units of the active ingredient are generally selected from the range of 0.01 to 1000 mg/kg, preferably 0.01 to 100 mg/kg, and more preferably 0.1 to 50 mg/kg, but the range will be readily determined by one skilled in the art depending on the route of administration, age, and condition of the patient. These dosage units may be administered one to ten times daily for acute or chronic disease. No unacceptable toxicological effects are expected when compounds of the invention are used in accordance with the present invention.

The invention compounds may be administered by any route suitable to the subject being treated and the nature of the subject's condition. Routes of administration include, but are not limited to, administration by injection, including intravenous, intraperitoneal, intramuscular, and subcutaneous injection, by transmucosal or transdermal delivery, through topical applications, nasal spray, suppository and the like, or may be administered orally. Formulations may optionally be liposomal formulations, emulsions, formulations designed to administer the drug across mucosal membranes or transdermal formulations. Suitable formulations for each of these methods of administration may be found in, for example, A. Gennaro, ed., *Remington: The Science and Practice of Pharmacy*, 20th ed., Lippincott, Williams & Wilkins, Philadelphia, PA.

Examples

The following Examples serve to illustrate the preparation, properties, and therapeutic applications of the compounds of this invention. These Examples are not intended to limit the scope of this invention, but rather to show how to synthesize and use the compounds of this invention.

Preparation of the Compounds of the Invention: General Procedures

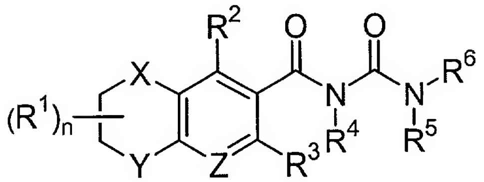
The following general procedures may be employed for the preparation of the compounds of the present invention.

The starting materials and reagents used in preparing these compounds are either available from commercial suppliers such as the Aldrich Chemical Company (Milwaukee, WI), Bachem (Torrance, CA), Sigma (St. Louis, MO), or are prepared by methods well known to a person of ordinary skill in the art, following procedures described in such references as Fieser and Fieser's *Reagents for Organic Synthesis*, vols. 1-17, John Wiley and Sons, New York, NY, 1991; *Rodd's Chemistry of Carbon Compounds*, vols. 1-5 and supps., Elsevier Science Publishers, 1989; Organic Reactions, vols. 1-40, John Wiley and Sons, New York, NY, 1991; March J.: *Advanced Organic Chemistry*, 4th ed., John Wiley and Sons, New York, NY; and Larock: *Comprehensive Organic Transformations*, VCH Publishers, New York, 1989.

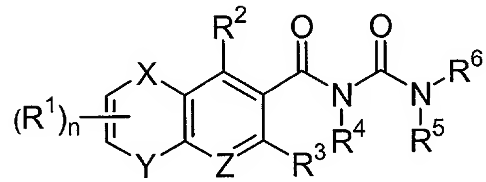
In some cases, protective groups may be introduced and finally removed. For example, suitable protective groups for amino, hydroxy, and carboxy groups are described in Greene et al., *Protective Groups in Organic Synthesis*, 2nd ed., John Wiley and Sons, New York, 1991. Activation of carboxylic acids can be achieved by using a number of different reagents as described in Larock, *Comprehensive Organic Transformations*, VCH Publishers, New York, 1989.

The starting materials, intermediates, and compounds of this invention may be isolated and purified using conventional techniques, including precipitation, filtration, distillation, crystallization, chromatography, and the like. The compounds may be characterized using conventional methods, including physical constants and spectroscopic methods.

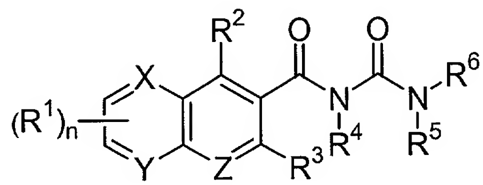
Generally, a compound of Formula I, II, or III:



I



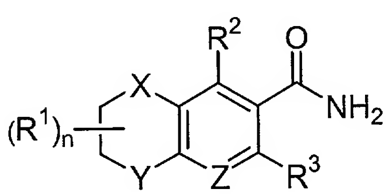
II



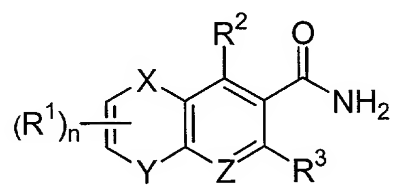
III

wherein X, Y, Z, and R^1 - R^6 are as defined in the Summary of the Invention, may be prepared by a process comprisingsaid process comprising:

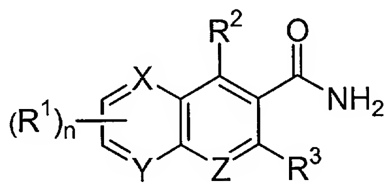
(a) contacting a compound of Formula Ib, IIb, or IIIb



Ib



IIb



IIIb

wherein X, Y, Z, and R^1 - R^3 are as defined above,

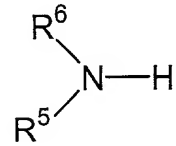
with a compound of the formula R^6-N=C=O

where R^6 is as defined above,

under appropriate conditions,

to produce a compound of Formula I, II, or III, wherein R^4 and R^5 are both H; or

(b) contacting a compound of Formula Ib, IIb or IIIb above with a haloformylation reagent and a compound of the formula



where R^5 and R^6 are as defined above,

under appropriate conditions,

to produce a compound of Formula I, II or III, wherein R^4 is H; or

(c) elaborating substituents of a compound of Formula I, II or III in a manner known *per se*; or

(d) reacting the free base of a compound of Formula I, II or III with an acid to give a pharmaceutically acceptable addition salt; or

(e) reacting an acid addition salt of a compound of Formula I, II or III with a base to form the corresponding free base; or

(f) converting a salt of a compound of Formula I, II, or III to another pharmaceutically acceptable salt of a compound of Formula I, II, or III; or

(g) resolving a racemic mixture of any proportions of a compound of Formula I, II, or III to yield a stereoisomer thereof.

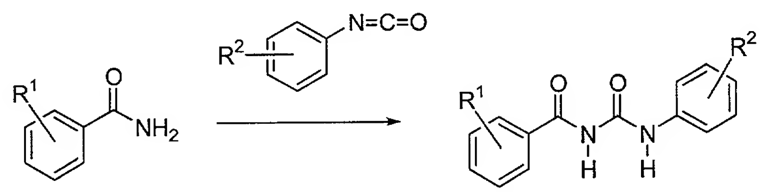
Step (a) may carried out in the presence of an organic solvent or a mixture of solvents at elevated temperatures, and the organic solvent may be toluene and the reaction may be carried out under refluxing conditions.

Step (b) may be carried out in an organic solvent or a mixture of solvents at elevated temperatures. The haloformylation reagent may be a compound of the formula A-(CO)-B wherein A and B are, independently, suitable leaving groups such as halogens, -COCl, -COBr and the like. The haloformylation reagent and organic solvent employed in step (b) may be oxalyl chloride and THF, respectively, and the reaction may be heated to above 50 °C.

The compounds of the invention can be synthesized as shown in the following examples. These examples are merely illustrative of some methods by which the compounds of this

invention can be synthesized, and various modifications to these examples can be made and will be suggested to a person of ordinary skill in the art having regard to this disclosure.

Procedure A:

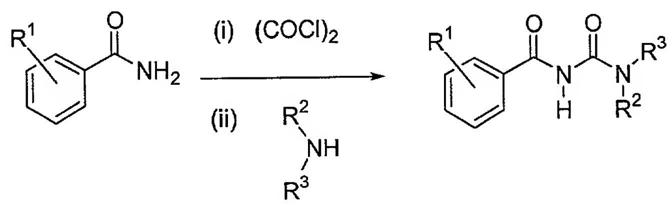


Compounds of the present invention may be prepared starting with a carboxamide and an isocyanate. Carboxamides and isocyanates starting materials may be purchased from various different commercial sources, such as, for example, the Aldrich Chemical Company, *supra*, or they may be prepared from standard procedures known in the art for preparing these compounds, such as the procedures described in the above cited references. The isocyanates may also be prepared according to the procedures described in the examples below. Typically, an aryl carboxamide is treated with an aryl isocyanate in an organic solvent or mixtures of suitable organic solvents. Preferably, the organic solvent is toluene. The carboxamide and the isocyanate may be combined as solutions or suspensions, depending on the solubilities of the compounds in the selected solvent. The carboxamide and the isocyanate may be added in a stoichiometric ratio (1:1), or a slight excess of the isocyanate may be used, for example between 1.01 fold and 2 fold excess, but typically about 1.01 to about 1.2 fold excess. Typically, the isocyanate is added to a suspension of the carboxamide in toluene, and the resulting mixture is heated until the reaction is determined to be complete. The reaction mixture may be heated at about 10 °C to about 150 °C, preferably at about 40 °C to about 120 °C under an inert atmosphere such as nitrogen, or the reaction mixture may be maintained at the refluxing temperature of the mixture. The reaction may be allowed to proceed to completion in about 10 minutes to 24 hours. Preferably, the reaction is heated to reflux until the reaction is complete, over about 6 to 24 hours.

Upon cooling of the reaction mixture, the resulting product may be isolated by conventional techniques. Typically, the product is isolated by filtration. The precipitated solid may be filtered, washed with a solvent or a series of solvents, and isolated without further

purification. Preferably, the precipitated product may be washed with a combination of toluene, methanol and then with ether, and the product may be dried under vacuum. If desired, the product may be further purified using conventional techniques, such as by recrystallization, chromatography, etc.

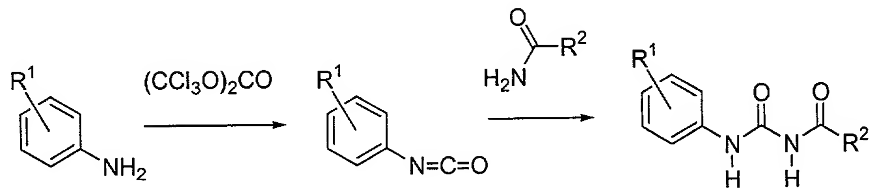
Procedure B:



The compounds of the present invention may also be prepared from the condensation of an isocyanate with an amine. The isocyanate may be prepared from the corresponding carboxamide or may be obtained from commercial sources. Depending on the desired substitution of the amine, optionally, the amine may be substituted with an amine protecting group, such that the protecting group may be removed in a subsequent step if desired. In the first step of the process, a carboxamide in a suitable aprotic solvent is treated with a carbonylation reagent to form the corresponding isocyanate derivative. Typically, the aprotic solvent is dichloromethane, toluene, 2-methyltetrahydrofuran or THF, and them carbonylation reagent is oxalyl chloride. Preferably, the aprotic solvent is dichloromethane. Oxalyl chloride is preferably present in an excess, for example, between 1.1 to 3.0 equivalents, typically about 1.5 equivalents, over the carboxamide. The reaction is generally performed under an inert atmosphere where the mixture is heated to 50 °C to 175 °C for 15 minutes to 24 hours or until the reaction is deemed complete. Typically, the reaction is heated to reflux over 2 to 16 hours under nitrogen, and then cooled to room temperature. The solvent is removed *in vacuo* by distillation, and the resulting isocyanate is then condensed with a primary or secondary amine. Condensation with the amine may be performed by the addition of a solution of the amine in an aprotic solvent, such as THF, under an inert atmosphere, at a temperature between 0 °C and 20 °C, preferably between 0°C and 5 °C. If the carbonylation and the subsequent condensation reaction are performed in the same solvent, the solvent removal step may be eliminated. Preferably, the reaction is performed at 0 °C to 5 °C for 1 to 24 hours, or until the reaction is complete. The solvent is removed by

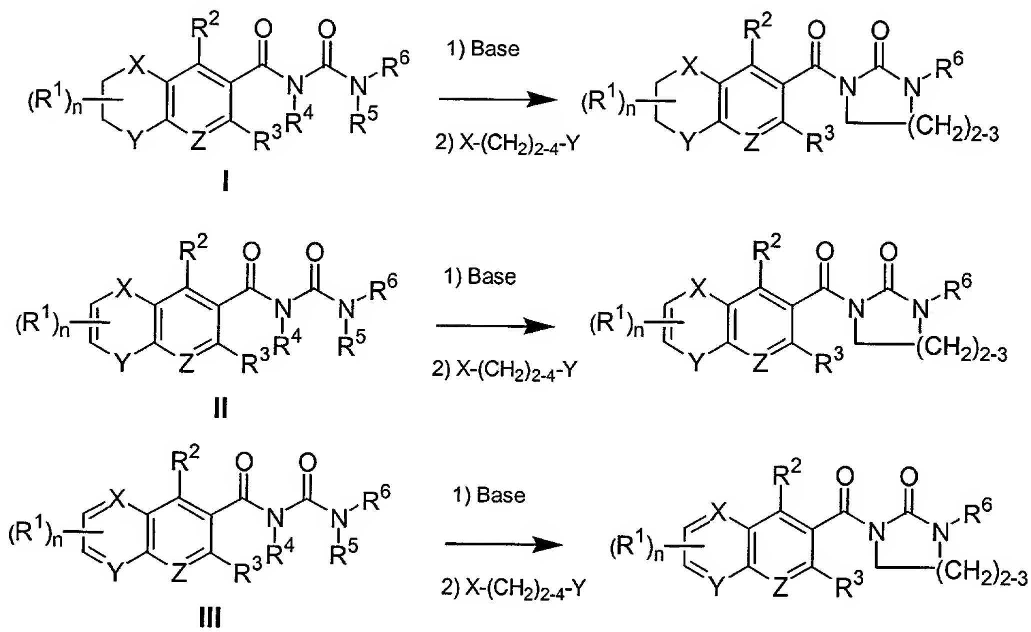
concentration under reduced pressure, and the product is isolated by conventional techniques such as filtration and washing of the crude product with a solvent followed by drying under vacuum, recrystallization, etc.

Procedure C:



The preparation of the compounds of the present invention may also be performed by condensation of an amine or aniline derivative with a phosgene equivalent, followed by reaction of the resulting isocyanate with a carboxamide. Typically, a solution of an aniline or aniline derivative and triphosgene in tetrachloroethane or other suitable organic solvent is combined and stirred at 25 °C to 80 °C under an inert atmosphere for 2 to 12 hours or until the reaction is complete as determined by TLC or HPLC analysis of the reaction mixture. The solvent is removed under reduced pressure and the residue is dissolved in an aprotic solvent, such as toluene, and the resulting mixture is treated with a carboxamide. The mixture is heated to about 50 °C to 150 °C, preferably from about 75 °C to 115 °C. More preferably, the reaction mixture is heated to reflux for 2 to 24 hours or until the reaction is complete, and allowed to cool to room temperature. The precipitated solid is isolated by conventional techniques such as filtration. The filtered solid is then washed with a suitable solvent or mixtures of solvents. Typically, the solid is washed with toluene, methanol and then ether, and the washed product is dried *in vacuo* to give the product.

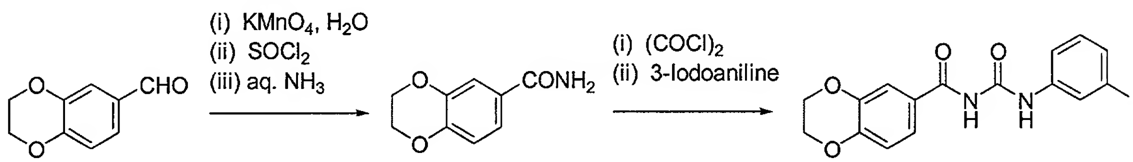
Procedure D:



Cyclic acyl ureas of the present invention may be prepared according to methods known in the art. One method comprises the alkylation of the acyl urea nitrogens with an alkylating agent generically represented above as X-$(CH_2)_{2\text{-}4}$-Y, where X and Y are leaving groups, and may be the same or different. Leaving groups known in the art include halides, methanesulfonates, trifluoromethanesulfonates, p-toluenesulfonates, p-bromotoluenesulfonate, p-nitrobenzenesulfonates and the like. Representative alkylating agents include 1,2-dibromo-ethane, 1,3-dibromoethane, 1,3-dibromopropane, and the corresponding sulfonates and mixed halosulfonates. Typically, the acyl urea is treated with a base in an organic solvent or mixtures of solvents. Preferably, the base is an inorganic base such as sodium hydride, or an organic base such as dimethyl sulfoxide and sodium hydride. Preferably, the solvent is a polar, aprotic solvent such as tetrahydrofuran, dimethylformamide, dimethyl sulfoxide, glycols, or mixtures of such solvents. Typically, a solution or suspension of the acyl urea is slowly added to the base in an organic solvent at about 0 °C to about 25 °C, and the resulting mixture is stirred for about 10 minutes to about 5 hours, preferably about 30 minutes. The alkylating agent is added and the mixture is stirred until the reaction is deemed complete. Alkylation of both urea nitrogens may be accomplished in a single step, or may be accomplished sequentially in a two step procedure

be exposing the partially alkylated product with the same or different base. The reaction is then quenched with a solvent, preferably water, and the mixture is extracted multiple times with an organic solvent. Preferably, the extracting solvent is dichloromethane. The combined organic extracts are washed with water, dried over anhydrous magnesium sulfate and concentrated under reduced pressure to afford the product, which may be purified using standard conditions known in the art. Purification may be performed by silica gel chromatography in a mixture of organic solvents, such as ethyl acetate and petroleum ether.

Example 1: 2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-*N*-{[(3-iodophenyl)amino]carbonyl}-carboxamide (**10**)

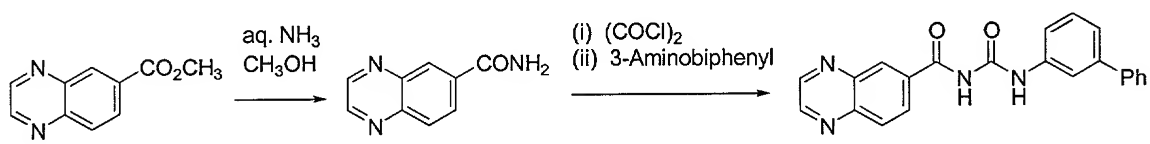


A solution of potassium permanganate (3.31 g) in water (100 mL) was added over 30 min to a stirred solution of 1,4-benzodioxan-6-carboxaldehyde (2.50 g) in water (40 mL) at 90 °C. Stirring was continued at 90 °C for an additional 45 min and the mixture was then cooled to ambient temperature. The mixture was made basic (pH 10) with aqueous 1M KOH solution, filtered, and the filtrate was cooled in an ice-bath and acidified to pH 3 with concentrated HCl. The precipitated solid was collected by filtration, washed with water, and dried. The solid was dissolved in dichloromethane, washed with saturated sodium chloride solution, and dried over magnesium sulfate. The solvent was evaporated under reduced pressure to furnish 2H,3H-benzo[e]1,4-dioxane-6-carboxylic acid as a white powder. A portion of this material (1.05 g) was dissolved in thionyl chloride (10 mL) and the mixture heated at 50 °C under a nitrogen atmosphere for 7 h. After cooling to room temperature, the excess thionyl chloride was removed under reduced pressure and the residue dried under high vacuum for 1 h. The solid was cooled in an ice-bath and treated with ammonium hydroxide solution (10 mL, 28-30% ammonia). The mixture was stirred at 0 °C for 5 min, and at room temperature for an additional 1 hr. The product was collected by filtration, washed with water and dried under high vacuum to provide 2H,3H-benzo[e]1,4-dioxane-6-carboxamide as a white powder. A portion of this material (0.90 g) was suspended in anhydrous dichloromethane under nitrogen and treated with oxalyl

chloride (3.8 mL of a 2M solution in dichloromethane). The mixture was heated at reflux for 15 h, cooled to room temperature, and concentrated under reduced pressure. The residue was dissolved in anhydrous tetrahydrofuran (10 mL), cooled in an ice-bath, and treated with 3-iodoaniline (604 μL). The ice-bath was removed and the reaction mixture was stirred at ambient temperature for 45 min. The resulting solid was filtered, washed with dichloromethane and methanol, and dried under high vacuum to produce the title compound as a white powder.

^{1}H NMR (DMSO-d_6) δ 4.29- 4.32 (m, 4H), 6.90 (d, 1H, J=8.3 Hz), 7.14 (t, 1H, J=7.9 Hz), 7.45 (d, 1H, J=7.9 Hz), 7.50 (d, 1H, J=6.8 Hz), 7.58- 7.61 (m, 2H), 8.10 (s, 1H), 10.88 (s, 2H). MS (ESI) m/z 423.

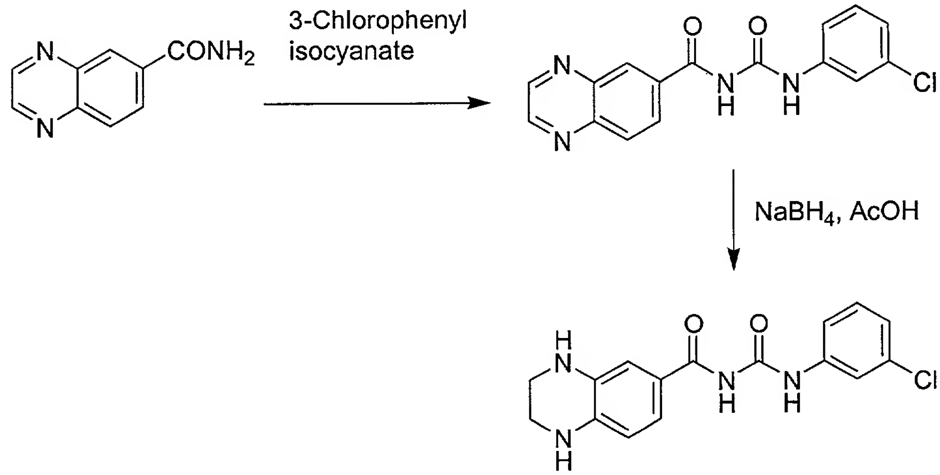
Example 2: N-{[(3-phenylphenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide (78)



A suspension of methyl quinoxaline-6-carboxylate (2.00 g) in methanol (7.0 mL) and 28-30% ammonia (14 mL) was stirred in a sealed tube at room temperature for 16 h. The precipitated solid was filtered, washed with water and dried under high vacuum to give quinoxaline-6-carboxamide as a white powder. A portion of this material (0.10g) was suspended in anhydrous dichloromethane and treated with oxalyl chloride (1.0 mL of a 2M solution in dichloromethane) under a nitrogen atmosphere. The mixture was heated at reflux for 16 h and concentrated under reduced pressure. The residue was dissolved in anhydrous tetrahydrofuran (1 mL) and added to an ice-cooled solution of 3-aminobiphenyl (0.98 g) in anhydrous tetrahydrofuran (1 mL). The mixture was stirred at room temperature for 2 h. The solvent was evaporated and the residue taken up in methanol and filtered to give N-{[(3-phenylphenyl)-amino]carbonyl}quinoxalin-6-ylcarboxamide as a white powder.

^{1}H NMR (DMSO-d_6) δ 7.37-7.47 (m, 3H), 7.50 (t, J=7.2 Hz, 2H), 7.65 (d, J=7.8 Hz, 1H), 7.69 (d, J=7.2 Hz, 2H) 7.91 (s, 1H), 8.25 (d, J=8.8 Hz, 1H), 8.37 (dd, J=8.8, 1.9 Hz, 1H), 8.84 (d, J=1.9 Hz, 1H), 9.09 (s, 2H), 10.85 (s, 1H), 11.44 (s, 1H). MS (ESI) m/z 369.

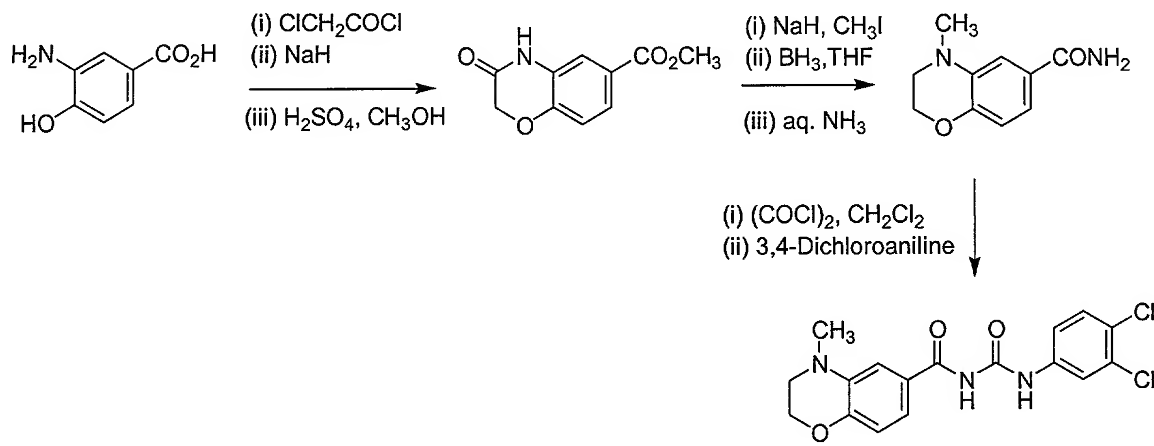
Example 3: N-{[(3-chlorophenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-yl-carboxamide (<u>**115**</u>)



Quinoxaline-6-carboxamide (0.10 g) was dissolved in hot toluene (30 mL) and azeotroped for 1 h. The solution was cooled to room temperature and treated with 3-chlorophenyl isocyanate (0.133 g). The mixture was heated at reflux for 16 h and then cooled to room temperature. The precipitated solid was filtered, washed with methanol, and dried under high vacuum to give N-{[(3-chlorophenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide as a white solid. A portion of this material (40 mg) was suspended in acetic acid (1.5 mL) in an ice-water bath, and the suspension treated with sodium borohydride (9 mg). After TLC showed complete consumption of the starting material, the solution was poured into water (20 mL). The precipitated solid was filtered, washed with water, and dried under high vacuum to give N-{[(3-chlorophenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide as a yellow solid.

^{1}H NMR (DMSO-d_6) δ 3.18 (br s, 2H), 3.32 (br s, 2H), 5.56 (br s, 1H), 6.37 (d, J=8.3 Hz, 1H), 6.38 (br s, 1H), 7.09 (d, J=1.9 Hz, 1H), 7.13 (dd, J=7.8, 1.9 Hz, 1H), 7.26 (dd, J=8.3, 1.9 Hz, 1H), 7.35 (t, J=7.8 Hz, 1H), 7.41 (dd, J=7.8, 1.9 Hz, 1H), 7.82 (t, J=1.9 Hz, 1H), 10.39 (s, 1H), 11.25 (s, 1H). MS (ESI) m/z 331.

Example 4: N-{[(3,4-dichlorophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[3,4-e]-1,4-oxazaperhydroin-6-yl))carboxamide (**141**)

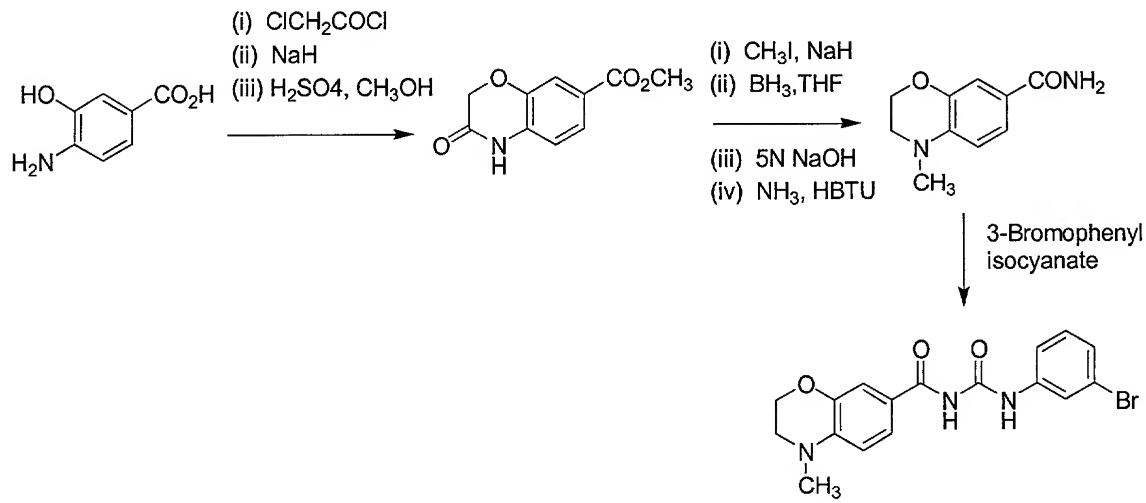


Chloroacetyl chloride (2.23 g) was added dropwise to a stirred suspension of 3-amino-4-hydroxybenzoic acid (3.00g) in anhydrous dichloromethane kept at -60°C under a nitrogen atmosphere. The cooling bath was removed and the mixture was stirred at room temperature for 16 h. Pyridine (9 mL) was added and the precipitated solid was collected by filtration, washed with methanol, and dried under high vacuum. A portion of this material (3.00 g) was suspended in anhydrous tetrahydrofuran (150 mL), cooled to –60 °C (dry ice/acetone) and treated with sodium hydride (2.10 g of a 60% suspension in mineral oil) under a nitrogen atmosphere. The cooling bath was removed and the mixture was stirred at room temperature for 16 h, quenched with methanol, and concentrated under reduced pressure. The residue was dissolved in water and acidified to pH 1 with concentrated HCl. The resulting precipitate was filtered, washed with water, and dried under high vacuum to give 3-oxo-2H,4H-benzo[e]-1,4-oxazaperhydroine-6-carboxylic acid. To a suspension of this material (2.80 g) in methanol (84 mL) was added sulfuric acid (0.5 mL) and the mixture was heated at reflux for 16 h. The solvent was removed under reduce pressure and the residue was resuspended in methanol and filtered to give methyl 3-oxo-2H,4H-benzo[3,4-e]-1,4-oxazaperhydroine-6-carboxylate. A suspension of this material (1.50 g) in anhydrous tetrahydrofuran (50 mL) was cooled to 0 °C and treated with sodium hydride (0.87 g of a 60% suspension in mineral oil). The suspension was stirred for 1 h and treated with iodomethane (3.08 g). The cooling bath was removed and the mixture was stirred at room temperature for 16 h, and quenched with methanol. The solvent was removed under

reduce pressure, and the residue was suspended in water, filtered, washed with water, and dried under high vacuum to afford methyl 4-methyl-3-oxo-2H-benzo[3,4-e]-1,4-oxazaperhydroine-6-carboxylate. A portion of this material (1.00 g) was dissolved in anhydrous tetrahydrofuran (50 mL) under nitrogen and treated with borane-tetrahydrofuran complex (7.5 mL of a 1M solution in tetrahydrofuran). The mixture was heated at reflux for 1 h, cooled to room temperature, and quenched by addition of methanol. The solvent was evaporated under reduce pressure and the residue was suspended in saturated sodium bicarbonate solution and extracted with dichloromethane. Concentration of the organic extract yielded methyl 4-methyl-2H,3H-benzo[3,4-e]1,4-oxazaperhydroine-6-carboxylate as a yellow oil. This material was dissolved in methanol (15 mL) and treated with 28-30% ammonia (30 mL). The mixture was stirred at room temperature for 16 h, and then treated with 5N NaOH solution. The precipitated solid was collected by filtration to give 4-methyl-2H,3H-benzo[e]-1,4-oxazaperhydroine-6-carboxamide as a white solid. A portion of this material (25 mg) was suspended in anhydrous dichloromethane (2.5 mL), and treated with oxalyl chloride (0.2 mL of a 2M solution in dichloromethane). The suspension was heated at reflux for 16 h and concentrated under reduced pressure. The residue was resuspended in anhydrous THF (0.5 mL) and added to an ice-cooled solution of 3,4-dichloroaniline (21 mg) in anhydrous tetrahydrofuran (1 mL). The mixture was stirred for 1 h and concentrated under reduced pressure. The residue was suspended in methanol, filtered, and washed with ether to give N-{[(3,4-dichlorophenyl)amino]carbonyl}(4-methyl-(2H,3H-benzo[3,4-e]-1,4-oxazaperhydroin-6-yl))carboxamide as a white powder.

^{1}H NMR (DMSO-d_6) δ 2.91 (s, 3H), 3.28 (t, J=4.1 Hz, 2H), 4.31 (t, J=4.1 Hz, 2H), 6.78(d, J=8.2 Hz, 1H), 7.37(d, J=8.2 Hz, 1H), 7.39 (s, 1H), 7.53 (dd, J=6.6, 2.2 Hz, 1H), 7.56(d, J=6.6 Hz, 1H), 8.02 (d, J=2.2 Hz, 1H), 10.94(s, 1H), 11.13 (s, 1H). MS (ESI) m/z 378.

Example 5: N-{[(3-bromophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[e]-1,4-oxazaperhydroin-7-yl))carboxamide (**144**)



4-Amino-3-hydroxybenzoic acid (5.00 g) was suspended in dichloromethane (200 mL) under a nitrogen atmosphere and cooled to –60 °C. Chloroacetyl chloride (3.72 g) was added dropwise, and the mixture was allowed to warm up to room temperature and stirred at this temperature for 16 h. Pyridine (15 mL) was added and the precipitated solid was filtered, washed with methanol, and dried under high vacuum to yield pyridinium 4-(2-chloroacetylamino)-3-hydroxybenzoate. A portion of this material (8.00 g) was suspended in anhydrous tetrahydrofuran (25 mL) under a nitrogen atmosphere and cooled to –60 °C. Sodium hydride (4.15 g of a 60% suspension in mineral oil) was added, the cooling bath was removed, and the mixture was stirred at room temperature for 16 h. It was then cooled to 0 °C, quenched by addition of methanol, and concentrated under reduced pressure. The residue was suspended in water and acidified to pH 1 with concentrated hydrochloric acid. The precipitated solid was filtered, washed with water, and dried under high vacuum to give 3-oxo-2H,4H-benzo[e]-1,4-oxazaperhydroine-7-carboxylic acid. A portion of this material (3.50 g) was suspended in methanol (115 mL) and treated with sulfuric acid (0.887 g). The mixture was heated at reflux for 16 h and cooled to room temperature. The precipitated solid was filtered, washed with methanol, and dried to give methyl 3-oxo-2H,4H-benzo[e]1,4-oxazaperhydroine-7-carboxylate. A portion of this material (2.00 g) was suspended in anhydrous tetrahydrofuran (100 mL), cooled to 0 °C, and treated with sodium hydride(0.77 g of a 60% suspension in mineral oil). The suspension was

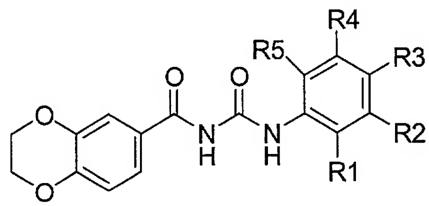
stirred for 1 h, treated with iodomethane (2.74 g), and the mixture stirred at room temperature for 16 h. The solvent was evaporated and the residue was suspended in ammonium chloride solution, filtered, washed with water, and dried under high vacuum to give methyl 4-methyl-3-oxo-2H-benzo[e]-1,4-oxazaperhydroine-7-carboxylate. A portion of this material (1.89 g) was suspended in tetrahydrofuran (100 mL) and treated with a 1M solution of borane-tetrahydrofuran complex in tetrahydrofuran (14.2 mL). The mixture was heated at reflux for 4 h and cooled to room temperature. The solvents were removed under reduced pressure and the residue was purified by column chromatography eluting with n-hexane/ethyl acetate to afford methyl 4-methyl-2H,3H-benzo[e]-1,4-oxazaperhydroine-7-carboxylate as a yellow solid. A portion of this material (0.53 g) was dissolved in methanol (5 mL) and 5N NaOH solution (2.55 mL) and the mixture was heated at reflux for 4 h. After cooling to room temperature, the mixture was diluted with water and acidified to pH 2 with concentrated hydrochloric acid. The precipitated solid was filtered, washed with water, and dried under high vacuum to give 4-methyl-2H,3H-benzo[e]-1,4-oxazaperhydroine-7-carboxylic acid as a white solid. A portion of this material (0.40 g) was suspended in a 0.5M solution of ammonia in dioxane (10.4 mL), and the suspension treated with diisopropylethylamine (1.34 g), *O*-(benzotriazol-1-yl)-*N,N,N',N'*-tetramethyluronium hexafluorophosphate (0.86 g) and DMF (5 mL). The mixture was stirred at room temperature for 16 h. The solvent was removed under reduce pressure, and the residue was purified by column chromatography eluting with dichloromethane/methanol to yield 4-methyl-2H,3H-benzo[e]-1,4-oxazaperhydroine-7-carboxamide. A portion of this material (0.10 g) was dissolved in hot toluene (30 mL) and azeotroped for 1 h. The solution was cooled to room temperature and treated with 3-bromophenyl isocyanate (0.226 g). The mixture was heated at reflux for 16 h, cooled to room temperature, and the precipitated solid was collected by filtration, washed with methanol and dichloromethane, and dried under high vacuum to yield N-{[(3-bromophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[e]-1,4-oxazaperhydroin-7-yl))-carboxamide as a white solid.

^{1}H NMR(DMSO-d_6) δ 2.96 (s, 3H), 3.39 (t, J=4.2 Hz, 2H), 4.22 (m, 2H), 6.73 (d, J=8.6 Hz, 1H), 7.24-7.36 (m, 2H), 7.42 (d, J=1.9 Hz, 1H), 7.47 (m, 1H), 7.64 (dd, J=8.6, 1.9 Hz), 7.98 (s, 1H), 10.68 (s, 1H), 11.16 (s, 1H). MS (ESI) m/z 388, 390.

Compounds of The Invention

The compounds shown in Tables 1-10 were prepared either by the procedures described above or by modifications of these procedures familiar to those skilled in the art.

Table 1



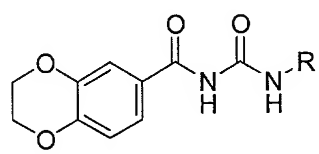
Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
1	H	Cl	H	H	H	332.74	331, 333
2	H	Cl	Cl	H	H	367.19	365, 367, 369
3	H	Cl	OH	H	H	348.74	347, 349
4	H	H	CF_3	H	H	366.29	365
5	H	H	Cl	H	H	332.74	331, 333
6	H	Br	H	H	H	377.19	375, 377
7	H	CN	H	H	H	323.31	322
8	Cl	H	Cl	H	H	367.18	365, 367, 369
9	H	H	I	H	H	424.19	423
10	H	I	H	H	H	424.19	423
11	H	OCF_3	H	H	H	382.29	381
12	H	i-Pr	H	H	H	340.38	339
13	H	Me	H	H	H	312.32	311

Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
14	I	H	H	H	H	424.19	423
15	H	CF_3	H	H	H	366.29	365
16	H	SCF_3	H	H	H	398.36	397
17	H	Et	H	H	H	326.35	325
18	H	OEt	H	H	H	342.35	341
19	H	Oi-Pr	H	H	H	356.38	355
20	H	Ph	H	H	H	374.39	373
21	H	t-Bu	H	H	H	354.40	353
22	H	Cl	Me	H	H	346.79	345, 347
23	H	I	Me	H	H	438.21	437
24	H	CF_3	Me	H	H	380.32	379
25	H	CF_3	F	H	H	384.28	383
26	H	CF_3	CF_3	H	H	434.29	433
27	H	CF_3	H	CF_3	H	434.29	433
28	H	CF_3	Cl	H	H	400.74	399, 401
29	H	OPh	H	H	H	390.39	389
30	H	NO_2	H	H	H	343.29	342
31	H	Cl	H	Cl	H	367.19	365, 367, 369
32	H	Ac	H	H	H	340.33	339
33	H	CO_2Me	H	H	H	356.33	355

Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
34	H	1H-1,2,3,4-tetrazol-5-yl	H	H	H	366.34	365
35	H	ethynyl	H	H	H	322.32	321
36	Me	Cl	H	H	H	346.77	345, 347
37	Me	H	H	Cl	H	346.77	345, 347
38	Me	H	H	I	H	438.22	437
39	OMe	H	H	Cl	H	362.77	361, 363
40	Et	Cl	H	H	Et	388.85	387, 389
41	H	1,3-thiazol-2-yl	H	H	H	381.41	382
42	H	2-thienyl	H	H	H	380.42	381
42	H	3-thienyl	H	H	H	380.42	379
44	H	2-furfuryl	H	H	H	364.56	363
45	H	2-pyridyl	H	H	H	375.38	374
46	H	H	1H-1,2,3,4-tetrazol-5-yl	H	H	366.34	365
47	H	CO_2Me	Br	H	H	435.22	435
48	H	CF_3	H	CO_2H	H	410.30	409
49	H	CF_3	H	OH	H	382.29	381
50	H	CO_2H	Br	H	H	412.20	419
51	H	Cl	$OC(O)CH_3$	H	H	390.77	389, 391
52	H	Cl	$OC(O)CH_2CO_2CH_3$	H	H	448.81	447, 449
53	H	Cl	$OC(O)CH_2CO_2H$	H	H	434.78	433, 435

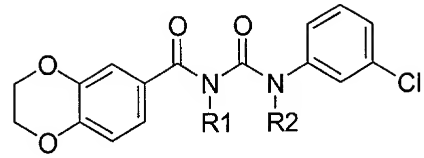
Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
54	H	Cl	$OCH_2CO_2CH_3$	H	H	420.80	419, 421
55	H	Cl	OCH_2CO_2H	H	H	406.77	405
56	H	Cl	$OCH_2CO_2CH_2Ph$	H	H	496.90	495, 497
57	H	Cl	CO_2Na	H	H	398.03	ND
58	H	CO_2H	Cl	H	H	376.75	375, 377
59	H	H	CO_2Na	H	H	364.28	ND
60	H	CO_2Na	H	H	H	364.28	ND

Table 2



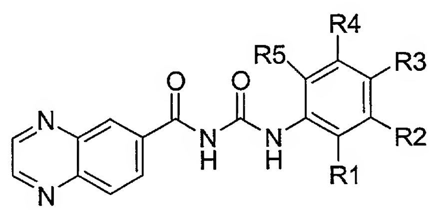
Compound	R	MW	MS (m/z)
61	2-chloro-4-(pyridyl)	333.73	333, 334
62	6-chloro-4-methylpyrimidin-2-yl	348.74	332, 334
63	5-(trifluoromethyl)(1,3,4-thiadiazol-2-yl)	374.30	373

Table 3



Compound	R1	R2	MW	MS (m/z)
64	CH_2OCH_3	CH_2OCH_3	420.84	421, 423
65	$CH_2OCH_2CH_2OCH_3$	H	420.84	421, 423

Table 4

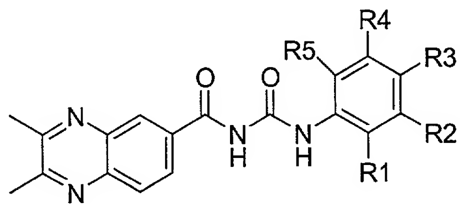


Compound	R1	R2	R3	R4	R5	MW	MS(m/z)
66	H	Cl	H	H	H	326.74	325, 327
67	H	Br	H	H	H	371.19	369, 371
68	H	H	CF_3	H	H	360.29	359
69	H	CF_3	H	H	H	360.29	359
70	H	OCF_3	H	H	H	376.29	375
71	H	i-Pr	H	H	H	334.38	333
72	H	I	H	H	H	418.19	417
73	H	CF_3	F	H	H	378.28	379
74	H	Cl	OH	H	H	342.74	343, 345
75	H	CF_3	Cl	H	H	394.74	395
76	H	CN	H	H	H	317.31	318

Compound	R1	R2	R3	R4	R5	MW	MS(m/z)
77	Cl	H	Cl	H	H	361.19	361, 363
78	H	Ph	H	H	H	368.39	369
79	H	Oi-Pr	H	H	H	350.38	351
80	H	OPh	H	H	H	384.39	385
81	H	CF_3	H	CF3	H	428.29	429
82	H	Cl	Cl	H	H	361.87	359, 361, 363
83	H	CO_2Me	Cl	H	H	384.78	383, 385
84	H	CO_2Et	Cl	H	H	398.80	397
85	H	CO_2Na	Cl	H	H	392.73	369, 371
86	H	H	CO_2Na	H	H	358.29	335
87	H	Cl	OCH_2CO_2Et	H	H	428.83	427
88	H	Cl	OCH_2CO_2Na	H	H	422.76	399, 401
89	H	CO_2Na	H	H	H	358.29	335
90	CO_2Na	Cl	H	H	H	392.73	371
91	H	Oi-Pr	CO_2Na	H	H	416.37	393
92	H	CO_2Na	H	CF_3	H	426.29	403
93	OH	Cl	H	H	H	342.74	341, 343
94	H	OH	CO_2H	H	H	352.30	351
95	H	3-thienyl	H	H	H	374.42	373
96	H	1,3-thiazol-2-yl	H	H	H	375.54	374
97	H	2-furfuryl	H	H	H	358.36	357
98	H	Cl	CO_2H	H	H	370.75	369
99	H	2-pyridyl	H	H	H	369.38	368
100	H	2-thienyl	H	H	H	374.42	373
101	H	OPh	CO_2H	H	H	428.40	427
102	H	benzoyl	H	H	H	396.40	395
103	H	CO_2i-Pr	Cl	H	H	412.83	411

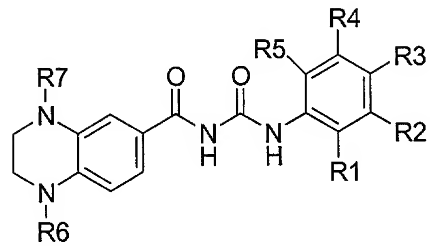
Compound	R1	R2	R3	R4	R5	MW	MS(m/z)
104	CO_2H	H	Cl	H	H	370.75	369
105	H	CF_3	CO_2Me	H	H	418.33	417
106	H	OH	CO_2Me	H	H	366.33	365
107	H	Cl	$OCH_2CO_2CH_2Ph$	H	H	490.10	489, 491
108	H	Cl	OCH_2CO_2H	H	H	400.06	399, 401

Table 5



Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
109	H	Cl	H	H	H	354.8	353, 355
110	H	Br	H	H	H	399.25	397, 399
111	H	CF_3	H	H	H	388.35	387
112	H	Cl	Cl	H	H	389.24	387, 389, 391
113	H	CN	H	H	H	345.36	344

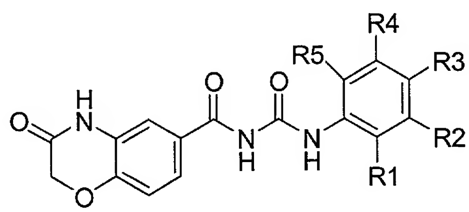
Table 6



Compound	R1	R2	R3	R4	R5	R6	R7	MW	MS (m/z)
114	H	H	CF_3	H	H	H	H	364.33	363
115	H	Cl	H	H	H	H	H	330.77	331, 333
116	H	Br	H	H	H	H	H	375.22	375, 377
117	H	CF_3	H	H	H	H	H	364.33	365
118	H	CF_3	H	H	H	Et	Et	420.43	421
119	H	OCF_3	H	H	H	H	H	380.32	381
120	H	i-Pr	H	H	H	H	H	338.41	339
121	H	I	H	H	H	H	H	422.22	423
122	H	CF_3	F	H	H	H	H	382.32	383
123	H	CF_3	H	H	H	Me	Me	392.38	393
124	H	CF_3	Cl	H	H	H	H	398.77	399, 401
125	H	CN	H	H	H	H	H	321.34	322
126	H	Ph	H	H	H	H	H	372.43	373
127	H	Oi-Pr	H	H	H	H	H	354.41	355
128	H	OPh	H	H	H	H	H	388.43	389
129	H	CF_3	H	CF_3	H	H	H	432.32	433
130	H	Cl	OH	H	H	H	H	346.77	345
131	H	CF_3	H	H	H	CH_2CH_2OH	CH_2CH_2OH	452.43	453
132	H	CF_3	H	H	H	H	CH_2CH_2OH	408.38	407

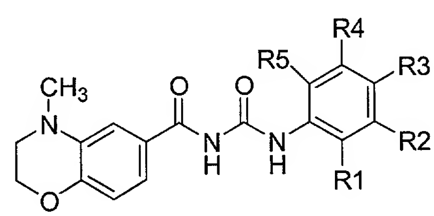
133	H	Cl	OCH_2-CO_2Et	H	H	H	H	432.86	431
134	H	CO_2Et	Cl	H	H	H	H	402.84	401
135	H	CO_2Na	Cl	H	H	H	H	396.76	373

Table 7



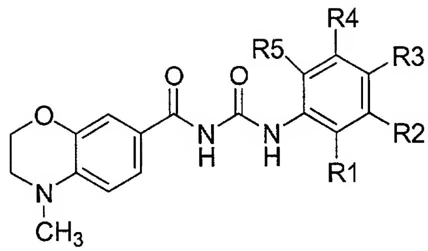
Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
136	H	CF_3	H	H	H	379.29	378
137	H	Cl	H	H	H	345.74	344, 346

Table 8



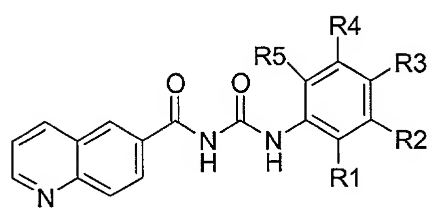
Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
138	H	Cl	H	H	H	345.78	344, 346
139	H	CF_3	H	H	H	379.37	378
140	H	Br	H	H	H	390.24	389, 391
141	H	Cl	Cl	H	H	380.23	378, 380, 382

Table 9



Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
142	H	CF_3	H	H	H	379.34	378
143	H	Cl	H	H	H	345.78	344, 346
144	H	Br	H	H	H	390.24	389, 391
145	H	Cl	Cl	H	H	380.23	378, 380,382
146	H	CF_3	H	CF_3	H	447.33	446
147	H	CN	H	H	H	336.35	335
148	H	CF_3	F	H	H	397.32	396

Table 10



Compound	R1	R2	R3	R4	R5	MW	MS (m/z)
149	H	Cl	H	H	H	370.20	368
150	H	Br	H	H	H	325.75	324, 326
151	H	CF_3	H	H	H	359.30	358
152	H	Cl	Cl	H	H	360.20	358, 360, 362

The names of the compounds shown in Tables 1-10 are given in Table 11. These names were generated with the Chemistry 4-D Draw™ software from ChemInnovation Software, Inc. (San Diego, CA).

Table 11

Compound	IUPAC Name
1	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-chlorophenyl)amino]carbonyl} carboxamide
2	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3,4-dichlorophenyl)amino]carbonyl} carboxamide
3	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-chloro-4-hydroxyphenyl)amino]carbonyl} carboxamide
4	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-({[4-(trifluoromethyl)phenyl]amino} carbonyl)carboxamide
5	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(4-chlorophenyl)amino]carbonyl} carboxamide
6	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-bromophenyl)amino]carbonyl} carboxamide
7	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-cyanophenyl)amino]carbonyl} carboxamide
8	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(2,4-dichlorophenyl)amino]carbonyl} carboxamide
9	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(4-iodophenyl)amino]carbonyl} carboxamide
10	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-iodophenyl)amino]carbonyl} carboxamide
11	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-({[3-(trifluoromethoxy)phenyl]amino} carbonyl)carboxamide
12	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-({[3-(methylethyl)phenyl]amino} carbonyl)carboxamide
13	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-methylphenyl)amino]carbonyl} carboxamide
14	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(2-iodophenyl)amino]carbonyl} carboxamide
15	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[3-(trifluoromethyl)phenyl]amino} carbonyl)carboxamide
16	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[3-(trifluoromethylthio)phenyl]amino} carbonyl)carboxamide
17	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-ethylphenyl)amino]carbonyl} carboxamide
18	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-ethoxyphenyl)amino]carbonyl} carboxamide
19	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[3-(methylethoxy)phenyl]amino} carbonyl)carboxamide
20	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-phenylphenyl)amino]carbonyl} carboxamide
21	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[3-(tert-butyl)phenyl]amino} carbonyl)carboxamide
22	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-chloro-4-methylphenyl)amino]carbonyl} carboxamide
23	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-iodo-4-methylphenyl)amino]carbonyl} carboxamide

Compound	IUPAC Name
24	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[4-methyl-3-(trifluoromethyl)phenyl]amino}carbonyl)-carboxamide
25	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[4-fluoro-3-(trifluoromethyl)phenyl]amino}carbonyl)-carboxamide
26	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[3,4-bis(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
27	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-({[3,5-bis(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
28	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-({[4-chloro-3-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
29	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-phenoxyphenyl)amino]carbonyl}carboxamide
30	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-nitrophenyl)amino]carbonyl}carboxamide
31	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3,5-dichlorophenyl)amino]carbonyl}carboxamide
32	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-acetylphenyl)amino]carbonyl}carboxamide
33	Methyl 3-{[(2H,3H-benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}benzoate
34	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-(1H-1,2,3,4-tetrazol-5-yl)phenyl)amino]carbonyl}carboxamide
35	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-ethynylphenyl)amino]carbonyl}carboxamide
36	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-chloro-2-methylphenyl)amino]carbonyl}carboxamide
37	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(5-chloro-2-methylphenyl)amino]carbonyl}carboxamide
38	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(5-iodo-2-methylphenyl)amino]carbonyl}carboxamide
39	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(5-chloro-2-methoxyphenyl)amino]carbonyl}carboxamide
40	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-chloro-2,6-diethylphenyl)amino]carbonyl}carboxamide
41	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-(1,3-thiazol-2-yl)phenyl)amino]carbonyl}carboxamide
42	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-(2-thienyl)phenyl)amino]carbonyl}carboxamide
43	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-(3-thienyl)phenyl)amino]carbonyl}carboxamide
44	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-(2-furyl)phenyl)amino]carbonyl}carboxamide
45	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(3-(2-pyridyl)phenyl)amino]carbonyl}carboxamide
46	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-{[(4-(1H-1,2,3,4-tetrazol-5- yl)phenyl)amino]carbonyl}carboxamide
47	Methyl 5-{[(2H,3H-benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-bromobenzoate
48	3-{[(2H,3H-Benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-5-(trifluoromethyl)benzoic acid
49	2H,3H-Benzo[e]1,4-dioxan-6-yl-N-({[3-hydroxy-5-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
50	5-{[(2H,3H-Benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-bromobenzoic acid

Compound	IUPAC Name
51	4-{[(2H,3H-Benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-chlorophenyl acetate
52	4-{[(2H,3H-Benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-chlorophenyl methyl propane-1,3-dioate
53	2-[(4-{[(2H,3H-Benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-chlorophenyl)-oxycarbonyl]acetic acid
54	Methyl 2-(4-{[(2H,3H-Benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-chlorophenoxy)acetate
55	2-(4-{[(2H,3H-Benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-chlorophenoxy)acetic acid
56	Phenylmethyl 2-(4-{[(2H,3H-benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-chlorophenoxy)acetate
57	Sodium 4-{[(2H,3H-benzo[e]1,4-dioxan-6-ylcarbonylamino)carbonyl]amino}-2-chlorobenzoate
58	5-{[(2H,3H-Benzo[3,4-e]1,4-dioxin-6-ylcarbonylamino)carbonyl]amino}-2-chlorobenzoic acid
59	Sodium 4-{[(2H,3H-benzo[3,4-e]1,4-dioxin-6-ylcarbonylamino)carbonyl]amino}benzoate
60	Sodium 3-{[(2H,3H-Benzo[3,4-e]1,4-dioxin-6-ylcarbonylamino)carbonyl]amino}benzoate
61	2H,3H-benzo[3,4-e]1,4-dioxin-6-yl-N-{[(2-chloro(4-pyridyl))amino]carbonyl}carboxamide
62	2H,3H-benzo[3,4-e]1,4-dioxin-6-yl-N-{[(6-chloro-4-methylpyrimidin-2-yl)amino]carbonyl}carboxamide
63	2H,3H-benzo[3,4-e]1,4-dioxin-6-yl-N-({[5-(trifluoromethyl)(1,3,4-thiadiazol-2-yl)]amino}carbonyl)-carboxamide
64	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-chlorophenyl)(methoxymethyl)amino]carbonyl}-N-(methoxymethyl)carboxamide
65	2H,3H-Benzo[3,4-e]1,4-dioxin-6-yl-N-{[(3-chlorophenyl)amino]carbonyl}-N-[(2-methoxyethoxy)-methyl]carboxamide
66	N-{[(3-Chlorophenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
67	N-{[(3-Bromophenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
68	Quinoxalin-6-yl-N-({[4-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
69	Quinoxalin-6-yl-N-({[3-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
70	Quinoxalin-6-yl-N-({[3-(trifluoromethoxy)phenyl]amino}carbonyl)carboxamide
71	N-({[3-(Methylethyl)phenyl]amino}carbonyl)quinoxalin-6-ylcarboxamide
72	N-({[3-(Methylethoxy)phenyl]amino}carbonyl)quinoxalin-6-ylcarboxamide
73	N-({[4-Fluoro-3-(trifluoromethyl)phenyl]amino}carbonyl)quinoxalin-6-ylcarboxamide
74	N-{[(3-Chloro-4-hydroxyphenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
75	N-({[4-Chloro-3-(trifluoromethyl)phenyl]amino}carbonyl)quinoxalin-6-ylcarboxamide
76	N-{[(3-Cyanophenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
77	N-{[(2,4-Dichlorophenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide

Compound	IUPAC Name
78	N-{[(3-Phenylphenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
79	N-({[3-(Methylethoxy)phenyl]amino}carbonyl)quinoxalin-6-ylcarboxamide
80	N-{[(3-Phenoxyphenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
81	N-({[3,5-bis(Trifluoromethyl)phenyl]amino}carbonyl)quinoxalin-6-ylcarboxamide
82	N-{[(3,4-Dichlorophenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
83	Methyl 2-chloro-5-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
84	Ethyl 2-chloro-5-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
85	Sodium 2-chloro-5-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
86	Sodium 4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
87	Ethyl 2-(2-chloro-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}phenoxy)acetate
88	Sodium 2-(2-chloro-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}phenoxy)acetate
89	Sodium 3-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
90	Sodium 6-chloro-2-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
91	Sodium 2-(methylethoxy)-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
92	Sodium 3-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}-5-(trifluoromethyl)benzoate
93	2-Chloro-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoic acid
94	2-Hydroxy-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoic acid
95	Quinoxalin-6-yl-N-{[(3-(3-thienyl)phenyl)amino]carbonyl}carboxamide
96	Quinoxalin-6-yl-N-{[(3-(1,3-thiazol-2-yl)phenyl)amino]carbonyl}carboxamide
97	N-{[(3-(2-Furyl)phenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
98	2-Chloro-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoic acid
99	N-{[(3-(2-Pyridyl)phenyl)amino]carbonyl}quinoxalin-6-ylcarboxamide
100	Quinoxalin-6-yl-N-{[(3-(2-thienyl)phenyl)amino]carbonyl}carboxamide
101	2-Phenoxy-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoic acid
102	N-({[3-(Phenylcarbonyl)phenyl]amino}carbonyl)quinoxalin-6-ylcarboxamide
103	Methylethyl 2-chloro-5-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
104	5-Chloro-2-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoic acid

Compound	IUPAC Name
105	Methyl 4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}-2-(trifluoromethyl)benzoate
106	Methyl 2-hydroxy-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
107	Phenylmethyl 2-(2-chloro-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}phenoxy)acetate
108	2-(2-Chloro-4-{[(quinoxalin-6-ylcarbonylamino)carbonyl]amino}phenoxy)acetic acid
109	2,3-Dimethylquinoxalin-6-yl)-N-{[(3-chlorophenyl)amino]carbonyl}carboxamide
110	(2,3-Dimethylquinoxalin-6-yl)-N-{[(3-bromophenyl)amino]carbonyl}carboxamide
111	(2,3-Dimethylquinoxalin-6-yl)-N-({[3-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
112	N-{[(3,4-Dichlorophenyl)amino]carbonyl}(2,3-dimethylquinoxalin-6-yl)carboxamide
113	(2,3-Dimethylquinoxalin-6-yl)-N-{[(3-cyanophenyl)amino]carbonyl}carboxamide
114	1,2,3,4-Tetrahydroquinoxalin-6-yl-N-({[4-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
115	N-{[(3-Chlorophenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
116	N-{[(3-Bromophenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
117	1,2,3,4-Tetrahydroquinoxalin-6-yl-N-({[3-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
118	(1,4-Diethyl(1,2,3,4-tetrahydroquinoxalin-6-yl))-N-({[3-(trifluoromethyl)phenyl]amino}carbonyl)-carboxamide
119	1,2,3,4-Tetrahydroquinoxalin-6-yl-N-({[3-(trifluoromethoxy)phenyl]amino}carbonyl)carboxamide
120	N-({[3-(Methylethyl)phenyl]amino}carbonyl)-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
121	N-{[(3-Iodophenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
122	N-({[4-Fluoro-3-(trifluoromethyl)phenyl]amino}carbonyl)-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
123	(1,4-Dimethyl(1,2,3,4-tetrahydroquinoxalin-6-yl))-N-({[3-(trifluoromethyl)phenyl]amino}carbonyl)-carboxamide
124	N-({[4-Chloro-3-(trifluoromethyl)phenyl]amino}carbonyl)-1,2,3,4-tetrahydroquinoxalin-6- ylcarboxamide
125	N-{[(3-Cyanophenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
126	N-{[(3-Phenylphenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
127	N-({[3-(Methylethoxy)phenyl]amino}carbonyl)-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
128	N-{[(3-Phenoxyphenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
129	N-({[3,5-bis(Trifluoromethyl)phenyl]amino}carbonyl)-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
130	N-{[(3-Chloro-4-hydroxyphenyl)amino]carbonyl}-1,2,3,4-tetrahydroquinoxalin-6-ylcarboxamide
131	[1,4-bis(2-Hydroxyethyl)(1,2,3,4-tetrahydroquinoxalin-6-yl)]-N-({[3-(trifluoromethyl)phenyl]amino}-carbonyl)carboxamide

Compound	IUPAC Name
132	[4-(2-Hydroxyethyl)(1,2,3,4-tetrahydroquinoxalin-6-yl)]-N-({[3-(trifluoromethyl)phenyl]amino}-carbonyl)carboxamide
133	Ethyl 2-(2-chloro-4-{[(1,2,3,4-tetrahydroquinoxalin-6-ylcarbonylamino)carbonyl]amino}phenoxy)acetate
134	Ethyl 2-chloro-5-{[(1,2,3,4-tetrahydroquinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
135	Sodium 2-chloro-5-{[(1,2,3,4-tetrahydroquinoxalin-6-ylcarbonylamino)carbonyl]amino}benzoate
136	(3-Oxo(2H,4H-Benzo[3,4-e]1,4-oxazaperhydroin-6-yl))-N-({[3-(trifluoromethyl)phenyl]amino}-carbonyl)carboxamide
137	N-{[(3-Chlorophenyl)amino]carbonyl}(3-oxo(2H,4H-benzo[3,4-e]1,4-oxazaperhydroin-6-yl))carboxamide
138	N-{[(3-Chlorophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[3,4-e]1,4-oxazaperhydroin-6-yl))-carboxamide
139	(4-Methyl(2H,3H-benzo[3,4-e]1,4-oxazaperhydroin-6-yl))-N-({[3-(trifluoromethyl)phenyl]amino}-carbonyl)carboxamide
140	N-{[(3-Bromophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[3,4-e]1,4-oxazaperhydroin-6-yl))-carboxamide
141	N-{[(3,4-Dichlorophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[3,4-e]1,4-oxazaperhydroin-6-yl))-carboxamide
142	(4-Methyl(2H,3H-benzo[e]1,4-oxazin-7-yl))-N-({[3-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
143	N-{[(3-Chlorophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[e]1,4-oxazin-7-yl))carboxamide
144	N-{[(3-Bromophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[e]1,4-oxazin-7-yl))carboxamide
145	N-{[(3,4-Dichlorophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[e]1,4-oxazin-7-yl))carboxamide
146	N-({[3,5-bis(Trifluoromethyl)phenyl]amino}carbonyl)(4-methyl(2H,3H-benzo[e]1,4-oxazin-7-yl))-carboxamide
147	N-{[(3-Cyanophenyl)amino]carbonyl}(4-methyl(2H,3H-benzo[e]1,4-oxazin-7-yl))carboxamide
148	N-({[4-Fluoro-3-(trifluoromethyl)phenyl]amino}carbonyl)(4-methyl(2H,3H-benzo[e]-1,4-oxazin-7-yl))carboxamide
149	N-{[(3-Chlorophenyl)amino]carbonyl}-6-quinolylcarboxamide
150	N-{[(3-Bromophenyl)amino]carbonyl}-6-quinolylcarboxamide
151	6-Quinolyl-N-({[3-(trifluoromethyl)phenyl]amino}carbonyl)carboxamide
152	N-{[(3,4-Dichlorophenyl)amino]carbonyl}-6-quinolylcarboxamide

Example 6: Inhibition of MCP-1 Induced Chemotaxis

A 96 well microchemotaxis chamber with a 5 µm-pore size, PVP-coated polycarbonate filter membrane (Neuro Probe Inc., Cabin John, MD) was used for testing. Compounds were prepared as 10 mM stock solution in DMSO. THP-1 cells ($2x10^6$ cells/mL) were labeled with 5 µM Calcein AM containing 0.1% F127 (Molecular Probe, Eugene, OR) at 37 °C for 30 min, and then pretreated with compound at room temperature for an additional 30 min. The lower chamber was loaded with medium containing 12.5 nM hMCP-1. The filter membrane was placed over the lower chamber, followed by a silicon gasket and the upper chamber. The pretreated THP-1 cells ($4x10^5$ cells/50µL of RPMI1640 medium per well) were added to the upper chamber and incubated in 5% CO_2 at 37 °C for 2 hr. The migrated cells were determined with a fluorescent plate reader (LJL BioSystems, Sunnyvale, CA). Table 12 shows the IC_{50} (concentration of compound that inhibited migration of 50% of the cells relative to control) for several compounds of the present invention.

Table 12. Effect of Compounds on MCP-1 Induced Chemotaxis

Compound	IC_{50} (µM)	Compound	IC_{50} (µM)	Compound	IC_{50} (µM)
1	0.577	3	4.339	5	>50
6	0.875	7	0.891	8	47.885
9	>50	10	0.204	11	10.476
12	0.789	15	3.433	18	2.836
19	0.355	20	1.46	24	0.068
25	0.026	26	4.213	27	0.406
29	0.024	30	2.022	31	1.555
32	0.788	35	0.380	36	0.133
37	8.741	38	8.743	39	8.797
41	0.065	42	0.238	43	0.173
44	1.367	45	0.364	61	3.103
66	3.585	67	7.479	68	2.72
69	0.775	70	1.764	71	0.493
72	3.429	73	0.629	74	1.491

Compound	IC_{50} (μM)	Compound	IC_{50} (μM)	Compound	IC_{50} (μM)
75	0.498	76	0.629	77	0.810
78	0.062	79	0.175	80	0.094
81	0.324	83	0.687	84	0.035
85	>50	86	36.829	88	>50
89	0.741	90	>50	91	0.266
92	>50	113	6.954	115	0.995
117	1.981	121	0.478	123	15.246
131	>50	135	>50	141	22.003
143	1.326	144	6.383	146	9.971
148	16.887	151	40.471		

Example 7: Thioglycollate-Induced Inflammation Model

3% Brewer's thioglycollate broth (Difco, Detroit, MI) was injected into the peritoneal cavity of ICR male mice, followed by subcutaneous administration of the test compounds at the same dose after 0 h, 3 h and 16 hours. After 96 h, the number of total elicited cells and MOMA2- positive cells in the peritoneal cavity was analyzed using an EPICS XL Beckman Coulter. The results are shown in Table 13.

Table 13.[a] Effect of Compounds on a Thioglycollate-Induced Inflammation Model

Compound	Dose (mg/kg)	Total Cells ($\times 10^6$)	MOMA2-positive Cells ($\times 10^6$)
No treatment	-	2.1 ± 0.3**	1.2 ± 0.2**
Control	-	24.4 ± 1.1	18.5 ± 0.9
55	10	14.1 ± 1.6**	10.1 ± 1.5**
59	10	17.3 ± 1.7**	13.2 ± 1.4**
Anti-MCP-1 Ab	1	12.3 ± 1.8**	8.8 ± 1.2**

[a]Anti-MCP-1 Ab was intraperitoneally injected.

Significant difference from control group: *P<0.05, **P<0.01 (ANOVA).

Example 8: Apolipoprotein E-Deficient Mouse Model

Apolipoprotein E (apoE) is a component of several plasma lipoproteins, including chylomicrons, VLDL, and HDL. Receptor-mediated catabolism of these lipoprotein particles is mediated through the interaction of apoE with the LDL receptor (LDLR) or with LDLR-related protein (LRP). ApoE-deficient mice exhibit hypercholesterolemia and develop complex atheromatous lesions similar to those seen in humans. The efficacy of the compounds of the present invention was also evaluated using this animal model.

Male, 4 week-old apoE-deficient mice were fed on high-fat diet (15% fat, 1.25% cholesterol). The test compound was administered as food admixture for 8 weeks. At 12 weeks old, the mice were fasted for 4 hours and then sacrificed under ether anesthesia. Blood was collected in the presence of heparin, and the hearts were perfused *in situ* with PBS (pH 7.4), followed by 4% paraformaldehyde for 5 min.

To determine cross-sectional lesion areas, the hearts were embedded in OCT compound and sectioned at 10 μm using cryostat. The sections were stained with oil red O. Each section of the aortic valve was evaluated for oil red O staining by capturing images directly from a RGB camera attached to a light microscope; image analysis was performed with the IPAP-WIN software (Sumika Tekno, Japan). Five sections were examined for each animal, and the sum of the lesion areas was calculated and expressed as the percent of the total cross-sectional wall area. Total cholesterol was determined with a Determiner assay kit (Kyowa Medex, Japan).

The effect of a representative test compound in this animal model of atherosclerosis is shown in Table 14.

Table 14.[a] Effect ofCompounds on the ApoE-Deficient Mouse Model of Atherosclerosis

Compound	Dose (mg/kg)	% Atherosclerotic Lesion (mean±SD)
Control	-	25.08 ± 6.93
<u>59</u>	50	21.08 ± 6.86
<u>55</u>	50	17.80 ± 3.43*

[a]Significant difference from control group: *P<0.05 (t-test).

Example 9: Caerulein-Induced Pancreatitis

Caerulein was injected intraperitoneally to male ICR mice every 1h for 6 h. The test compound was given orally immediately after the caerulein injection, and then again at 3 h and 6 h. After 15 h, the mice were sacrificed and their blood was collected and analyzed for serum amylase activity as a marker of pancreatitis.

The effect of a representative test compound is shown in Table 15.

Table 15.[a] Effect of Compounds on Caerulein-Induced Pancreatitis

Compound	Dose (mg/kg)	Serum Amylase Level (U, Caraway, mean±SD)
No Treatment	-	1079 ± 98
Control	-	1531 ± 279
<u>57</u>	20	551 ± 157**
Anti-MCP-1	1	1104 ± 222

[a]Significant difference from control group: **P<0.05 (LSD).

Example 10: Oral pharmaceutical composition - Solid dosage formulation

A pharmaceutical composition for oral administration may be prepared by combining the following:

	<u>% w/w</u>
Compound of this invention	10.0
Magnesium stearate	0.5
Starch	2.0
(hydroxypropyl)methylcellulose	1.0
Microcrystalline cellulose	86.5

The mixture may be compressed to tablets, or filled into hard gelatin capsules. The tablet may be coated by applying a suspension of film former (*e.g.*, (hydroxypropyl)methylcellulose),

pigment (*e.g.*, titanium dioxide) and plasticiser (*e.g.*, diethyl phthalate) and drying the film by evaporation of the solvent. The film coat can comprise 2.0% to 6.0% of the tablet weight, preferably about 3.0%.

Example 11: Oral pharmaceutical composition preparation - Softgel

A pharmaceutical composition of a compound of the invention suitable for oral administration may also be prepared by combining the following:

	% w/w
Compound of this invention	20
Polyethylene glycol 400	80

The medicinal compound is dispersed or dissolved in the liquid carrier, with a thickening agent added, if required. The formulation is then enclosed in a soft gelatin capsule by suitable technology.

Example 12: Pharmaceutical composition for parenteral administration

A pharmaceutical composition for parenteral administration may be prepared by combining the following:

	Preferred Level (%)
Compound of this invention	1.0
Saline	99.0

The solution is sterilized and sealed in sterile containers.

Various modifications and variations of the present invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as disclosed should not be unduly limited to such specific embodiments. Various modifications of the described modes for carrying out the invention which are obvious to those skilled in the art are intended to be within the scope of this invention.